HISTORY AS POINTS AND LINES

by Yuri Tarnopolsky and Ulf Grenander

Manuscript

1998-2003
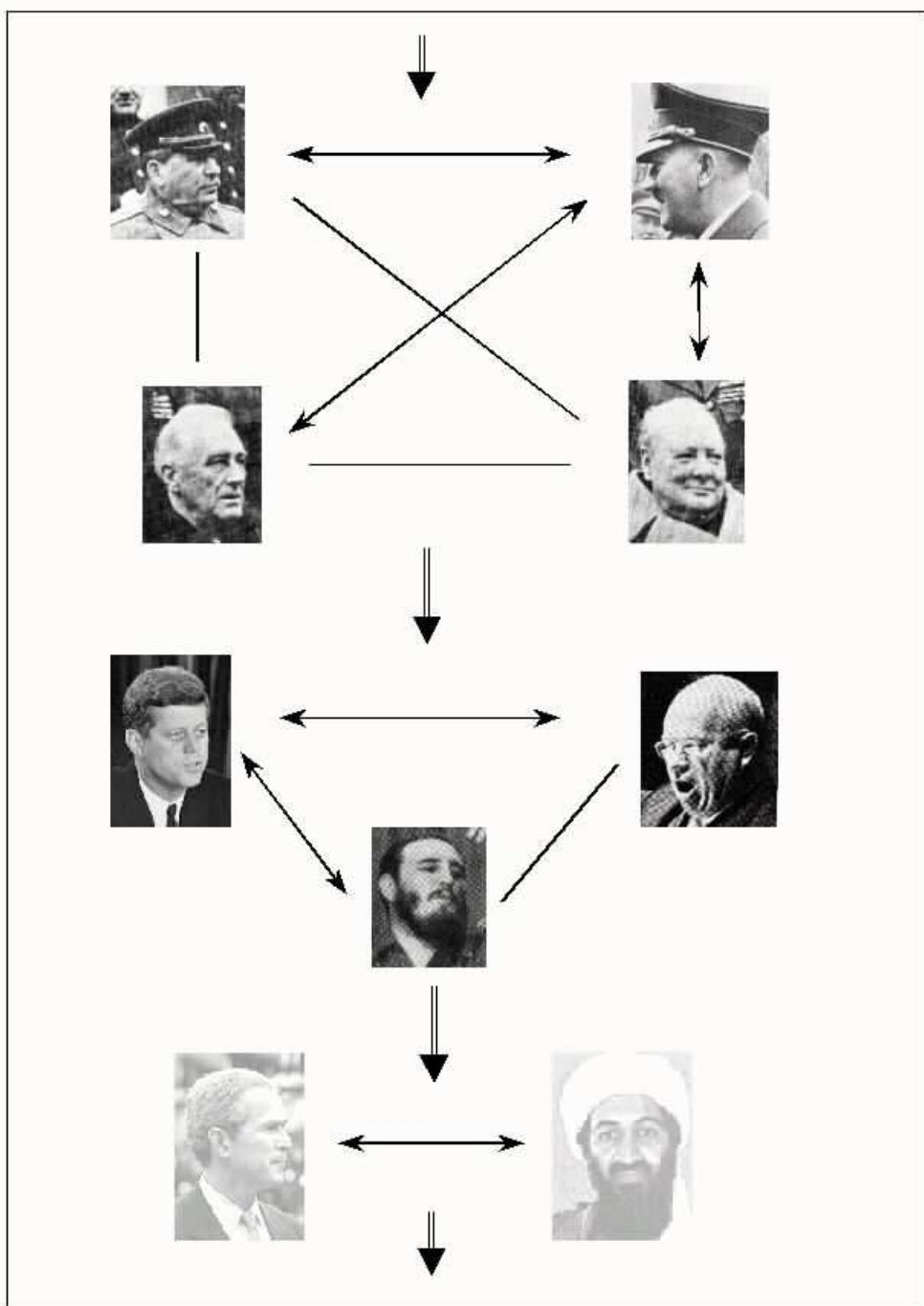
Foreword (2006)

Most of this manuscript was finished by 1998. In 2001 the world entered a turbulent transition state toward an unknown future. In 2003 we added Chapter 28, *A sunny day in September* .

Facing global uncertainty from many directions—climate change, energy constraints, new forms of warfare, borderless world, incompetence of governments—we need to look for a scientific consensus on complexity, as opposed to the divisive political, moral, and religious approaches. Testing the ideas of this book against the dramatic beginning of the twenty-first century, we feel confident that the pattern view of the world can be an effective way to understand the developing systems of unprecedented complexity.

The intent of this manuscript is to attract attention to Pattern Theory as the science of complex systems. Complexity as subject presumes a complex audience. The style reflects our desire to educate, stimulate, and entertain, while introducing the reader to new and little known or forgotten ideas.

The manuscript does not reflect the recent developments in non-numerical Pattern Theory, among which *Patterns of Thought* by Ulf Grenander should be mentioned in the first place. *Patterns and Repertoire in History* by Bertrand M. Roehner and Tony Syme (Harvard University Press, 2002) was an important step toward the legitimization of the search for new ways in scientific study of history. Jared Diamond's *Collapse: How Societies Choose to Fail or Succeed* (Viking, 2004) approaches the subject from a different angle but remarkably close to the spirit of Pattern Theory.

Our manuscript is a register of questions rather than answers, but, as the history of science demonstrates, the right question is half the answer.

CONTENTS

PROLOGUE

Change must follow a pattern or leave us unaware of its existence.

G.J.Renier (Renier, 1965, p. 229).

History and mathematics—can they be put side by side in any sense? Well, it is possible:

...some people dislike the study of history, just as others dislike the study of mathematics... (Brinton, 1956, p. 3)

What about history and chemistry?

History is the most dangerous product developed by the chemistry of the intellect. (Valéry, 1962, p. 114).

Taking history and mathematics, do they have anything to tell each other?

Wrestling of arguments, clash of opinions, and animosity of contradicting evaluations never end in history. Mathematical proof is either correct or not: a proved theorem is proved for everybody. Since ancient times history has been a captivating reading. Mathematics is a patented source of headache. History seems to be of no immediate practical value—a dynamic society buries the dead and goes on. Mathematics brings to life all modern technology. History is art, with Clio as its muse, and mathematics is notoriously dry.

Nevertheless, the serious answer is a firm "yes." Since Pitirim Sorokin (1937) filled the four volumes of his *Social and Cultural Dynamics* with numbers attached to events of the past, scores of textbooks and papers on quantitative methods in history have appeared. There are sites on the World Wide Web on the use of computers in history, college courses, software for historians, and scientific societies.

More confusing questions arise: what is mathematics in the era of computers and what is history in the era of sociology? What is history—facts? What is mathematics—numbers? Furthermore, what is truth? Isn't this book an experiment à la Doctor Moreau in creating yet another chimera and more confusion?

This book, written by a mathematician and a chemist, is an experiment, as we hope, in fusion rather than confusion. It is definitely neither about history of mathematics nor about chemistry nor about numbers and calculations.

We are not going to do any historical research, for which we, due to our backgrounds, are not equipped. Our sources on history are mostly textbooks and selected books for general audience. Our knowledge of the subject, except for the events of the twentieth century that we personally witnessed, is secondhand. We offer neither interpretation, nor explanation, nor evaluation. Neither do we want to "open eyes" nor to offer "the real thing." We do not engage in

polemics. At this point we are not much interested even in the historical truth itself. The reasons for such an apparently radical statement will be explained gradually.

We might have overlooked some sources that expressed similar or same ideas in the past . We might have unwillingly taken liberties with historical facts. We cannot provide any consistent review of the literature, the volume of which enormous. We take fragments of historical knowledge without critical assessment and use them as experimental material.

The purpose of our experiment is to place history on the examination table of a certain apparatus which works like an X-ray machine or CAT scan. Our apparatus is mental rather than metal. It is called *pattern theory*, a new area of mathematics that was developed by one of the authors and accidentally discovered by the other. We want to take a look at history not because we search for any hidden defects, but because we can place under scrutiny of pattern theory literally everything.

Here is an excerpt from the list of subjects pattern theory considers:

Automatic target recognition, body movements, behavior, mathematical logic, growth and decay, language, human and animal skeletons, grammars, mathematical functions, automata, industrial processes, weave patterns of fabric, molecules, handwriting, spectra, cockroach's legs, human hands, the crust of the earth, genealogy, plots of novels and fairy tales, archaeology, motion of planets, kinship relations, botanical taxonomy, scientific hypotheses, social dominance, language, anatomy, and much more—actually, anything.

So, why not history, more captivating than any fairy tale, the greatest and longest novel ever written, full of suspense, tragedy, and hope, with heroes and monsters of global proportions?

The comparison with X rays, however vague, is meaningful for us. We can examine with X rays a multitude of totally unrelated objects as different as live human hand, Rembrandt's painting, Egyptian mummy, horse's leg, and the suitcase of an airline passenger. What we see in each of them is a black-and-white shadow with very little resemblance of what is seen on the surface. It can be easily scanned and reduced to a long sequence of numbers stored in computer memory, each presenting the darkness or brightness of a certain point. All X ray photos, so put it bluntly, are made of the same black and white stuff, although they are derived from strikingly different objects. They revoke the shadows on the wall of the Plato's cave.

What unites all those heterogeneous objects is that they are complex and have structure invisible by a naked eye. As viewed through the mental imaging apparatus of mathematics, they may look surprisingly similar: like points connected with lines.

Not accidentally, the application of pattern theory to understanding medical imaging is one of the fastest growing. Here we are attempting to apply the same principles to the body of historical narrative. What we expect to see is its hidden skeleton in motion.

Following this analogy, we will first try to show how to produce the image of the skeleton, and, secondly, speculate on how to understand what it tells us.

If it turns out that a historical narrative and events behind it cast the same shadows of the wall of the Plato's cave as horse, suitcase, and chemical reaction in a test tube, this would mean that history, regardless of its content, joins the world of dissimilar objects built along similar principles. We hope to understand something new about the unity of the world.

Of course, history is such a colorful subject that we will not resist the temptation to put some flesh on the mathematical bones.

Since our experiment is first of the kind, we cannot promise too much. If, however, it stimulated a historian to repeat it in a professional fashion, we would say that our expectations were exceeded.

The general mindset of pattern theory is not alien to modern culture and we believe that the reader will easily recognize its relation to past and current trends. There is a far more general relation, however.

The second half of the twentieth century was deeply imprinted by a dichotomy that Charles P. Snow (1959) had attributed to the contemporary culture. He saw an impenetrable divide between people living in two immiscible media—natural sciences and liberal arts. His motto about two cultures is still echoed by polemic responses. We can mention David Edgerton (1997) and John Brockman (1995). The slow process of fusion goes on in the new century and in quite unexpected directions, as the recent *The Sociology of Philosophies* by Randall Collins (1998) illustrates.

C. P. Snow's troubling picture of the alienation of two subcultures that could not find the common language lost after Lucretius, Leonardo da Vinci and Goethe was definitely exaggerated even in his time: Albert Einstein played violin. At present, both opposites—digerati and literati—are separated by a very diffuse border.

And yet driving along the less traveled route from Physics to Poetry, we feel how the landscape, vegetation, the color of the skies, and the language of aborigines changes, and somewhere after the exit to Psychology and passing the exits to Sociology and History, we arrive at a different world.

Among the major changes, we would certainly notice the fading presence of mathematics (statistics is the last to wither), the growing presence of images and metaphors, the declining

power of logic, and the rising spontaneity of self-expression. The mathematician calls many things with one name, while the poet calls one thing with many names.

The transition can hardly be compared with the abyss, chasm, or canyon: it is gradual, but as distinct as the change of climate along a meridian from Mexico to Canada.

When we compare two sketches of Leonardo da Vinci, Figure P.1, as symbols of the two cultures, they seem to contrast as sharply as a poem and a theorem. Is there any way we can bridge them? The simplified truss bridge in the picture presents a simple *pattern* of identical triangles with joint edges. We can see a high degree of regularity in this pattern: the upright triangles alternate with triangles upside down. We can describe the pattern of the bridge in a few words of common language, extend it in any direction, and apply to indefinite number of similar bridges.

When we looking at the world as a collection of patterns, it loses most of its color, smell, weight, texture, beauty, and other material and spiritual qualities. It looks like the shadows of X rays. We can code the skeletons of things in sequences of numbers, as in digital photography, but the core of what they tell us can be expressed in points and lines.

For some readers points and lines may invoke the childhood's nightmare of a geometry textbook. The image of history which is one for everybody, like the multiplication table, could be terrifying. It would be only natural to doubt whether we can gain anything by applying any stern ascetic approach to liberal arts such as history, flapping in the transient winds of today's political weather and full of life, color, mood, and bias. Note, however, that if numbers are present in a textbook of geometry, it is mainly as page numbers: geometry is an example of mathematics

without numbers. It was this kind of mathematics that Spinoza tried to apply to philosophy in his *Ethics*.

Figure P.1. Two sketches by Leonardo da Vinci represent the worlds of art and science
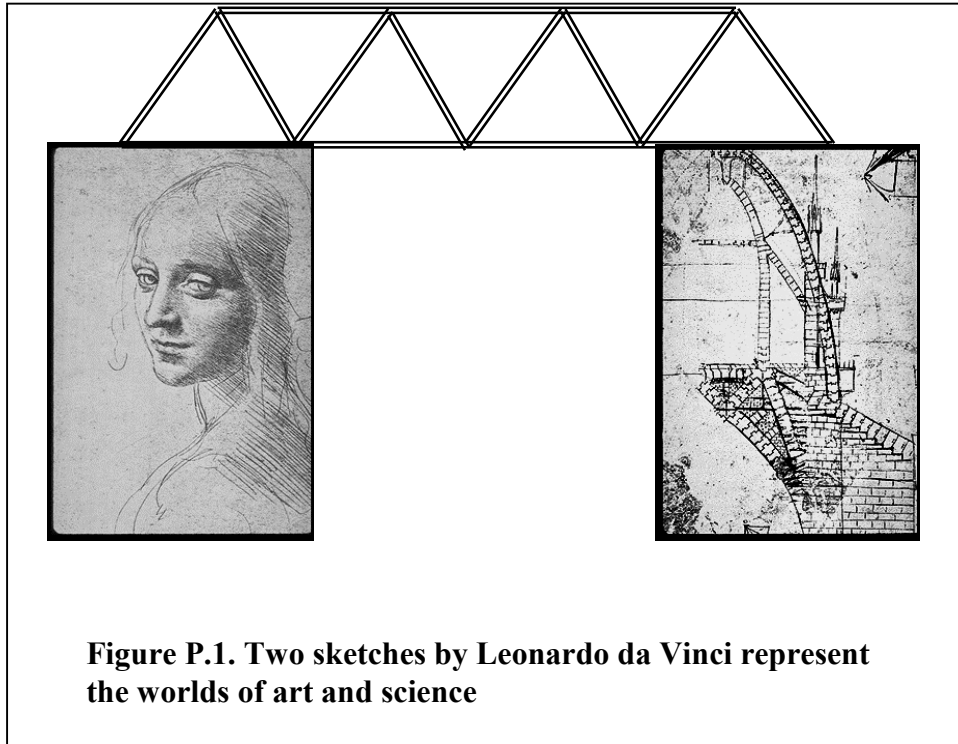
The kind of mathematics we are trying to betroth to history is even more liberal than geometry: neither angle nor length complicates the picture.

Whether the marriage can take place, we cannot tell. But with a mutual curiosity on both sides, computers are the most powerful marriage brokers of our time.

Our primary goal here is to draw attention of new intellectual adventurers to pattern theory and provide them with the basic tools that one of the authors developed.

In a greatly simplified form, here is the essence of our experiment.

Pattern theory offers a way to represent knowledge in terms similar to the basic terms of chemistry, i.e., atoms and bonds between them. The "atoms" of pattern theory are called *generators* and "bonds" are called *bond couples*. The "molecule" is called *configuration*. Pattern theory is a formal mathematical theory of all such objects, including real molecules. What makes pattern theory unusual is that it attributes a certain probability to every "bond." It is a study of probabilities on structures. Some bonds, therefore, are "stronger" than others, and some configurations are more probable than others, which translates probability into energy.

What it does is quite remarkable: not only we can give a unified way to describe various objects of any complexity, but we can start discussion of transformation of objects in the same terms, whether the object is a curve of a screen saver, situation in the Middle East, movements of the ballerina on the stage, evolution of mammal scull, fermentation of grape juice into wine, and the torments of a smoker who wants to quit. Some configurations are stable and lasting, others, like the 24 hours of the day of Presidential Elections of 2000, are unstable, fuzzy, transient, and short-living.

If we cut the process into stages, the questions that can be asked in such discussion are: what is the initial state of a change ? what are possible final states? which final state is more probable? what are the transition states? which transition states are more probable? which pathway from the initial state to which final state is more probable?

This seems like a very intangible kind of discussion, especially if we are frustrated by the TV reports from the hot spots of the globe. Nevertheless, having started this discussion around the subject of history—ancient, as well as in the making—we will touch upon less abstract questions:

what is complexity?
can complexity be simplified?

what can we see in genealogy?
is history a natural process?
why do events happen?
why some events do not happen?
what is historical turmoil?
what influences the outcome of events?
can the future be predicted?
what do we mean when we say "raising the bar?"
what do we mean when we say "hot issue?"
why did WWIII not happen?
what is the pattern difference between China and Russia?
is the pattern of a terrorist organization familiar?
are the tall buildings doomed to fall?
what is social work?
what is social heat?

And, of course, we will explain how we understand what pattern is. To give an idea, we do not offer a new theory of history, but, rather, try to generalize how events happen, whether real or imaginary. For example, *Romeo and Juliet* and *West Side Story* are two different stories, but when one story is transformed into another, the *pattern* is preserved. Similarly, as the reader will see, we find an essentially same pattern in two different revolutions separated by 150 years and the English Channel, seen as La Manche from the other side.

Our approach is more general than that of a historian and it may raise some eyebrows. If this is a theory, then it is a theory of histories, as a theory of folk tales (Propp, 1968) is not a treatise on the properties of dragons and magic swords but an analysis of what remains constant when we jump from tale to tale. The reader who wants to understand this book has to follow the authors all the way. Since it uses history as the illustrative material, it picks up something of the properties of the subject: an event of history, like a detective novel, unfolds between the beginning and the end, and so does this book.

In first fifteen chapters we browse through some episodes of history, share some observations on the use of geometrical imagery in the works of historians, and prepare the reader

to handling a few basic mathematical, physical, and chemical ideas such as binary relation, graph, transformation, group, atomism, and principles of thermodynamics. We want to show that most of those ideas have always been secretly present in works of historians and sociologists. At the same time we want to locate our own place among different views of the world.

In Chapter 16 we present the basics of the concept of pattern. We formulate the ideas of generator, bond couple, regularity, bond relation, transformation, etc., certainly, with much less rigor than it is done in original sources.

Next, we add more examples and look into dynamic aspects of regularity and structural change, and the phenomenon of catalysis which is more general than chemists and stock market veterans might believe. In Chapters 22 to 25 we apply our tools to some large historical developments and formations. In the Chapters 26 and 27 we cast some looks into the future.

We wish history did not give us an opportunity to add Chapter 28 prompted by the tragedy of September 11, 2001. It was, however, a typical case of transition from one configuration to another, which is essentially the subject of this book. We would like to take this yet unfinished transition as another illustration of our approach.
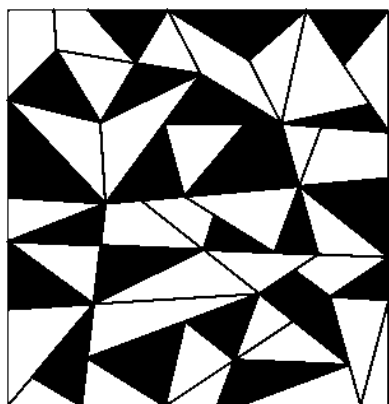
We assume that most readers are very far from mathematics, physics, and chemistry. We prefer images, illustrations, and metaphors to formalism. Instead of a systematic layout of the subject, we draw it as a visual puzzle, like Figure P.2, where the viewer is invited to find a star. First, all we see are black and white polygons. Suddenly, we notice the star and after that we can never "unsee" it.

Figure P.2. Find a star

We promise to help notice the stars hidden in the pages of this book, but the reader should stay alert.

The following Chapter 1, for example, helps the reader to notice the persistent tendency of our mind to find connections between different things and ideas. The initial mosaic is a collection of various stories and anecdotes. The abstract concept of relation is the first star.

1. *Post hoc, ergo propter hoc*

The title of this chapter means "after this, therefore because of this" It is the Latin term for a common logical error of concluding that if one event precedes another, it causes it. Very often it does, and the lightning causes the subsequent thunder, but it would be erroneous to conclude that it also causes the rain to follow.

Let us respect errors: life on Earth, as some scientists believe, was a chemical error that, luckily, multiplied itself. Error may be the seed of new truth.

The logical error turned to be very productive at the very dawn of the human understanding of the world because it had shaped the very concept of cause and effect. The world appeared not as a flurry of sensations, but as a system of lasting links and permanent bonds. Human knowledge became to grow and evolve as a tribal hut grows when branches are tied together in a stable structure that can be changed, repaired, or abandoned altogether.

Making tools involves physical links, for example, between the head and the shaft of the spear. The causal link is different from the physical link: it is invisible and we can comprehend it only with our mind.

 The hypertext link of the web page is significantly "dematerialized" because it is a state rather than physical body and to establish or break it requires a very small amount of energy. Apparently, an idea, for example, causality, truth, or guilt, has a similar fragile nature in our brain, but this is not so simple. It is equally easy to type a word into computer memory or erase it, but to make people abandon their ideas or acquire new ones is a hard work.

Anyway, the Internet link is our first example. A heavy iron bridge can be next. Looking at an iron bridge, we can clearly see its structural elements and the way they are riveted, bolted, or welded together. The immaterial ideas display a similar design.

Since the very beginning of history people believed that some ideas would stick together and some would not. They used to build models of the world basing on some assumptions about their properties.

From the start of human quest for understanding the surrounding world, it was very important to find some guidelines to distinguish the observations that have some affinity to each other from those that do not want to be close in any sense, as well as from those that have no apparent preference whatsoever, like the content of computer memory.

Thus, *ad hoc ergo propter hoc* was an obvious way of driving a rivet through the right hole while building the structure of knowledge. Although the lightning and the rain do not always follow each other, it happens *often enough*. In mathematics, the vague *often enough* is quantified by probability.

There were also more sophisticated ways to establish a link. Pre-scientific ideas often express the belief that similar acts are in some way attracted to each other so that if one act is performed, then the other is likely to follow. This underlies the imitative magic whose basis is therefore more theoretical than empirical.

> In Thüringen the man who sows flax carries the seed in a long bag which reaches from his shoulders to his knees, and he walks with long strides, so that the bag sways to and fro on his back. It is believed that this will cause the flax crop to wave in the wind. In the interior of Sumatra the rice is sown by women who, in sowing, let their hair hang loose down their back, in order that the rice may grow luxuriantly and have long stalks
>
> One of the principles of sympathetic magic is that any effect may be produced by imitating it. To take a few instances If it is wished to kill a person an image of him is made and then destroyed; and it is believed that through a certain physical sympathy between the person and his image, the man feels the injuries done to the image as if they were done to his own body, and that when it is destroyed he must simultaneously perish. (Frazer, 1981, p.9).

The modern burning of the flag or the enemy leader in effigy, as well as the revulsion toward burning the national flag, seem to come from the same ancient belief.

The search for rules or regularity in establishing links goes back at least six thousand years, as the rich written heritage of Mesopotamia testifies. The people there made their conclusion basing on extremely superficial similarity, sometimes based on the sound of the word. The following illustration may seem too technical, but it gives us a unique opportunity to look right into the mind of ancient people:

> Moreover, it seems that such observations must have led them [Babylonians] to wonder to what extent the following events could not have been *not only preceded,* but *also announced* by the

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antecedent ones, precisely because of the idea that they had of both the role of the gods and of the mysteries of their writing system. It goes without saying that we do not know how and when they became aware of that but to the extent that we can take as historical the following passage of another treatise on hepatoscopy [divination on liver], also from the Old Babylonian period, we can formulate some idea on it by way of hypothesis: *If in the liver, on the right hand side of the gall bladder two clearly marked perforations* (Akkadian *pilšu) are pierced (palšu): this is the omen of the inhabitants of Apišal whom Narâm-Sîn* (fourth king of the Akkad dynasty: between 2254 and 2218 B.C.) *made prisoner by means of a breach in the wall (pilšu).* Once more, if the fact is authentic, we would have a double reason to relate the two oracular elements, the omen and the prediction, to each other. Not only had the observation of a strange liver perforated in this way preceded the capture of the southern city of Apišal by a breach in the wall, but the wording of the omen and that of the oracle were tied by characteristic similarities in sound: the perforations (pilšu) pierced *(palšu)* in the liver evoked not only the breach (pilšu) but the name of the conquered city *(Apišal),* by a slight consonantal metathesis (Bottéro, 1992, p. 37).

For a similar reason, it is not done in China to make a gift of four things: the words four and death in Chinese sound alike—yet another example of the strength of mental bonds that are stronger than iron.

James Frazer's famous book was first published in 1890 and after many subsequent editions is still in print. It was motivated by the search for certain elementary motives—patterns, as we would say—that "have operated widely, perhaps universally, in human society, producing in varied circumstances a variety of institutions specifically different but generically alike" (Frazer, 1981).

All our knowledge seems to stem from coupling similar things. The identification of two fish with two fingers of the hand was probably the very beginning of mathematics. We can see the same trend of connecting identical or similar things in the ancient practice of magic, divination, and astrology, still in demand, and still influencing the travel schedules of an occasional American president.

The human ability to link events by conspicuous similarity attracted attention of Plutarch, the founder of history.

In his biography of Gaius Marius, Plutarch tells the anecdote about Marius' childhood: "For when he was a boy and was still living in the country, he had caught in his cloak an eagle's nest, with seven eaglets in it, as it was falling." His parents consulted the prophets and were told that Marius "was fated seven times to hold the supreme power and authority" (Plutarch, 1988, p. 50)

Marius was a Roman general and consul. After his sixth consulate the circumstances made Marius a fugitive, powerless, in great misery, with the family myth as the only source of strength and will.

To Plutarch's credit we must say that, as any modern scientist would do, he gathered all the available evidence for and against this story, including the biological fact that the eagle rears not more than two eaglets. Nevertheless, the fact is that Marius returned to Rome, took a bloody revenge over his enemies, and died seventeen days after he became consul for the seventh time.

Both Plutarch's suspicion about the whole story as well as the attention he gave it were well founded. But let us put ourselves in the position of a Roman citizen: Marius's success in the form of his seventh consulate, unprecedented in the history of Rome, needed an explanation. Marius's fate, linked through the mere number seven to another event, albeit fictional, did not seem isolated, independent, and irregular anymore: it was not a prank of chaos. There must have been a reason for everything.

The driving impulse behind the human attempts to find the link between similar things was to overcome the isolation of facts and observations, to find regularity in the endless flow of sensations, and extract order from the surrounding chaos. One s*even* sticks to another *seven*, as

the *holes* in the liver stick to the *holes* in the wall of a Mesopotamian city. We pull one *seven* and the other *seven* follows as if tied by a cord.

How successful this method was, the fate of Octavius, the defender of Rome against Marius, illustrates. "A number of Chaldaean astrologers, professional inspectors of sacrifices, and interpreters of the Sibylline books had induced him to believe that all would be well," Plutarch writes. Octavius, however, had been killed even before Marius entered Rome. Plutarch denounces Octavius for spending more time with "charlatans and soothsayers than with men of political or military distinction." An yet at the end Plutarch wonders: "It was something not very easy to explain—that one of these two famous leaders, Marius, did well through paying attention to prophesies, while the other, Octavius, was destroyed by them."

At the end of this book we will return to the problem of prophesy. Here we can see scientific thinking right in the moment of its birth from superstition. Plutarch noticed that two implications of the same "theory" were leading to a contradiction and the theory did not hold water. This is a remarkable step toward science: Plutarch and other thinkers of antiquity explored links not only between objects of the external word, observable with the senses, but also between ideas. They did it by the same rules as we do, following Aristotle who lived almost half millennium before Plutarch and twenty-three centuries before us.

Some ideas linked naturally, as a bird and its nest, and some did not, as a lion and a fire. *Prophesy* and *prophesy* stick together, but *he did well* and *he was destroyed* do not stick. Unlike *lion* and *fire*, their repulsion is mental and not material. In the search for regularity in these relationships, Aristotle created formal logic, and the newborn science found a firm ground under its feet.
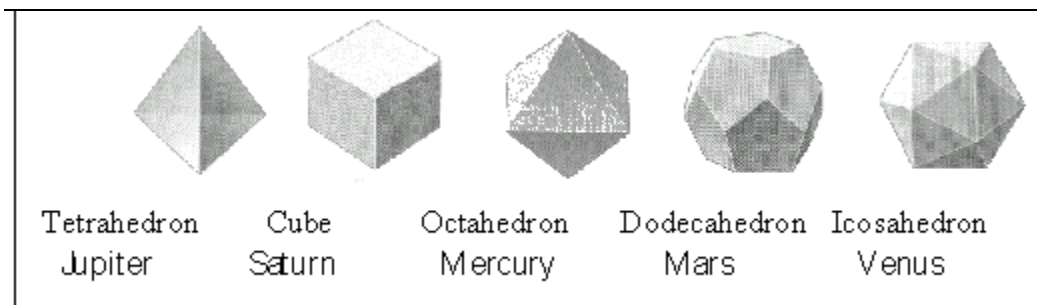
Figure 1.1. Platonic solids and planets associated to them by Kepler

The pattern of drawing the picture of the world from superficial similarities is noticeable in many religious, moral, or philosophical doctrines, from the belief of Ancient Egyptians in the afterlife (we need food, so do the dead), to racism (they do not look like us, so they neither think nor feel same way). A more intricate systems of parallels may lie behind the Biblical concept of origin of species or the New Age belief in the power of a crystal pyramid.

Johannes Kepler (1571-1630) concluded that there were only six planet known by the time because there were five Platonic solids, three-dimensional figures with high degree of symmetry, see Figure 1.1. Since the Earth was "the measure of all things," it did not need any solid of its own.

For Kepler's contemporaries and historians of science it was a daring and elegant construct. In our time the scientists announce a harsh judgment:

To a scientist today it may seem a scandal that one of the founders of modern science should invent such a fanciful model of the solar system (S. Weinberg, 1992, p. 164).

Clearly, he [Kepler] was most pleased with what he had done. The only problem is that it is all nonsense! (Devlin, 1994).

Kepler, however, simply continued the same uninterrupted search for links and connections that we can trace from the ancient cultures to modern science and philosophy. The scientist needs to hold on to something in his or her perpetual climbing the vertical wall, and in Kepler's time, the number of hooks to affix a conjecture was too limited.

Even now chemists are guided in their choice of a solvent by an old empirical rule: similar dissolves similar. The difference is, however, that they know both empirical and theoretical justification of the rule.

Science had been driven toward a minimum of contradiction and disharmony in the picture of the world. While it is possible to make people believe in two contradicting things by propaganda, it requires substantial efforts and constant work.

> In modern times the whole advertising industry is based on the ability of human mind to jump to superficial associations (Pratkanis, 1992).

American teenagers believe that if they have the same basketball shoes as a sports star has, they will play as good as he and make the same career. The stars aside, a teenager boy wearing the same clothes as his peers does not feel isolated any more. A newcomer to the world, linked to it by the shoestrings of his sneakers, he is as comforted as Marius, former six times powerful Roman consul, hiding in the woods on a hostile coast, exhausted and hungry, was comforted by the mysterious number seven, which he believed would pop up again in his life.

Humans came to this world with tools, aware of the physical bond between the arrowhead and the stick, mallet and its handle, thread and needle. This kind of link can be explored in all detail and reproduced many times. At the next step of evolution, the ancient observers of the world noted that there were invisible immaterial links between objects and

events, some easily understandable, like the bonds of kinship, and some mysterious, like the bond between the rain dance and the rain.

The rain did not always follow the rain dance, but sometimes it did. The sun always rose after the Aztec human sacrifice, and even, defiantly, without it. It was too early for the probability theory, however. Today, the link between smoking and lung cancer is established by using statistics in tandem with the principle *ad hoc, ergo propter hoc*.

When two events always or very often occur together, there is, *probably*, a positive link between them. If two events never or rarely occur together, there is, *probably*, a negative link between them. To evaluate probability, however, requires accumulating a database for statistics because probability makes sense only over a multitude of observations. The old Latin warning simply means that a single coincidence does not constitute a causal link.

In criminal justice, to show how the crime was committed, the prosecution must demonstrate the causality in the sequence of events, similar to showing how to tie the arrowhead to the arrow and head the thread through the needle. This complete sequence of causal links is called *mechanism* in chemistry as well as biology, history, economics, and engineering. We will return to mechanism in Chapter 14, *Fermentation in Wine Barrel and Society*.

The thrill of both detective story and science comes from the effect of the missing link of the mechanism. Justice may fail because some incredible things happen with a low probability, but a detective story does not work if it is too predictable.

The clockwork mechanism embodies the principle of the perfect causal link, which we can trace from the spring, pendulum, or battery to the movement of the clock's hands. The realization that our world is not as perfect as the clockwork was quite traumatic when physics

discovered the world of elementary particles. Even Albert Einstein denied that God could roll a dice.

Since history seems to be built of unique cases, there is no statistics of American or French revolutions in the sense that we have a multitude of them. An important question is whether such mechanisms can always be established. Even if we pool together all the revolutions in the world, we may not be able to arrive at a generalization for the causal link of revolutionary terror. In what sense can history be a science and not just a narrative?

As a preliminary observation, we need to apply efforts to keep in the mental picture some elements that repel each other, while others are naturally attracted. We have to spend energy to break the seemingly superstitious associations—they might turn up not so false after all but simply ahead of time.

We will return later to the probabilistic interpretation of a link and its connection with the concept of energy and affinity.

Evolution of human knowledge started with recognition of separate elementary objects and observations and establishing links between them. With time, natural sciences, religion, arts, and humanities went their separate ways.

Here we regard any particular work of a historian, from Plutarch to Niall Ferguson, as a doctrine, i.e., a system of statements about the world, regardless of whether it is true or not. Be it the story of Marius or of World War I, we do not try to prove it, criticize, or find the truth, but are more interested in the internal structure and properties of a doctrine, and if it is a story, we are interested in the *mechanism* of its unrolling. Our secret and, probably, at this stage unfounded hope is to find the general rules of structural change regardless of the particularities of the structure.

Facts for us are also doctrines. The fact has no lifetime warranty and it may turn out a hoax or an illusion. If we have a set of something presented to us as facts, we are not trying to verify them but take them for granted and examine how they fit the doctrine. Our approach, therefore, is *formal,* as appropriate for mathematics. Naturally, having been spectators and participants of the history of most of the twentieth century, we might have our own idiosyncrasies.

We talked lines, what about the points?

2. Atomism

The examples in the previous chapter—just a few from an endless list—can be formally represented by lines of two kinds: ——— for attraction (positive bond) and ←———→ for repulsion (negative bond).

$$\text{long hair} \text{———} \text{long rice}$$

$$\text{five Platonic solids} \text{———} \text{five planets}$$

$$\text{he did well} \leftarrow\text{———}\rightarrow \text{he was ruined}$$

$$\text{smoking} \leftarrow\text{———}\rightarrow \text{good health}$$

Similarity of different things, as we have seen, is a very ancient observation. Most fish are similar in the outline of their body, and so are birds, conifers, and many other groups of objects. Yet the ancient people went much further in the interpretation of similarity. The ancient belief that similar attracts similar reveals the idea that certain things are connected and others are not, and the connection has something of an attraction of a mother to her child, a lion to a

tethered goat, or a piece of iron to a magnet. One needs to do some physical work and exert energy in order to separate all those couples.

The next step in establishing connections was to recognize the importance of dissimilar or even the opposite phenomena, which may struggle and annihilate each other. We can see that motive in many religions: God and Devil in Christianity, Truth and Lie in Zoroastrianism, Yang and Yin in Chinese Naturalism, and earth, air, fire, and water of Aristotle.

In other words, certain things in nature and human mind have *affinity*, while others do not, and some even repel each other. Thus, fire scares off night predators, the cross keeps off the devil, nature is afraid of void, garlic scares off vampires, and macho behavior intimidates the rival.

At the very dawn of science a cardinal idea was expressed by the Greek philosopher Democritus: the world consists of atoms—certain building blocks or primitives. This idea was taken up by Epicures in Rome. His follower and popularizer Lucretius wrote a large poem *On the Nature of Things*.

> But powerful in old simplicity,
> Abide the solid, the primeval germs;
> And by their combinations more condensed,
> All objects can be tightly knit and bound
> And made to show unconquerable strength.
>
> (Lucretius, 1958)

"Tightly knit and bound" is already a beginning of pattern thinking, especially if we note that atoms were to Lucretius not only the building blocks of matter, but the very foundation of all

what was built on it, including mind and social life. Like atoms in the Periodic Table, the unchangeable primeval germs were for him the carriers of order. Be it otherwise,

> Nor could the generations
> Kind after kind so often reproduce
> The nature, habits, motions, ways of life,
> Of their progenitors.

In the spirit of atomism, Lucretius discussed the shape of objects, expressing the important for pattern theory idea (physicists may find here the starting idea of quantum physics):

> ...these primal germs
> Vary, yet only with finite tale of shapes.
> For were these shapes quite infinite, some seeds
> Would have a body of infinite increase.
> For in one seed, in one small frame of any,
> The shapes can't vary from one another much.

Lucretius also regarded language as a combination of standard elements:

> The words and verses differ, each from each,
> Compounded out of different elements...

We quote Lucretius at length because the idea of combinatorial atomism, central in this book, comes from the ancient atomism: we are proud of a respectable genealogy.

When we try to represent knowledge from some domain by pattern-theoretic methods, the first, and perhaps most difficult question to be answered is what primitives and blocks are suitable for building such structures? To choose the building blocks is a crucial and difficult step

when building a representation. No simple recipes can be offered; only some general and necessarily somewhat vague advice.

The development of the atomic theory of matter can point us in the right direction and we are indebted with that to Democritus and Lucretius. After them the theory then had become dormant for a long time until it was revived and deepened by Dalton and other chemists in the late eighteenth and early nineteenth century.

Far from believing in the *real* existence of atoms, even as late as the 1900's, prestigious natural philosophers preferred to think of the concept as a hypothesis, useful but not established. While Democritus in the fifth century B.C. believed that only the atoms and void were real, Ernst Mach *ca* 1900 regarded atoms only as a postulate.

In a naive view the atoms could be thought of as small rubber balls bouncing against each other and the containing walls, resulting in an irregular motion otherwise called heat. Based on this assumption the discipline of statistical mechanics was developed and used as the theoretical underpinnings of thermodynamics, one of the great success stories of modern science.

We will talk more about thermodynamics later, but here we would like to note that it is much more than a chapter of physics. In fact, thermodynamic is universal.

> Thermodynamics is more like a mode of reasoning than a body of universal physical law; wherever it applies it always allows us to justify the use of the same principles...(S. Weinberg, 1992, p. 41).

In spite of the triumph of science, one could still question the physical reality of atoms, especially as quantum mechanics, emerging in the 1920's, replaced the classical view of material particles by a less intuitive one. Some would argue that the concept of atom is just a shorthand description of certain measurements that differ from one element in the periodic system of

Mendeleyev to another. In other words, atoms were man-made concepts, extremely useful but not as real as the rubber balls.

The subsequent developments of science left no doubt about the existence of atoms. In the most recent time we have even learned to see and move single molecules and manipulate matter atom by atom, as we move word by word with the word processor.

The analogy between atoms of matter and more abstract building blocks of the world should not go too far, and yet in the same way as physics initially perceived atoms, we shall think of our building blocks, to be called *generators*, as man-made, designed by a researcher for a specific purpose, whether they can be attributed existence in the real world or not. Their purpose is to help in organizing a body of knowledge, to make it appear simple, and to make it cohesive. Sometimes it is obvious how to create useful generators, other times it will require a deeper understanding of the domain of knowledge.

Remarkably, all modern science looks for the relations between apparently disconnected things as diligently as the ancient fortune-tellers looked for the relations between the entrails of the sacrificed animals and the outcome of a marriage or war. Edward B. Tylor, one of the founders of cultural anthropology, and J.G.Frazer, the author of *The Golden Bough*, both interpreted magic as pseudo-science.

Anthropologists differ in their interpretation of the subject, but if we consider the search for bonds, links, and regularities as the driving force of understanding the world, we can trace the origin of science from mythology and magic to present. The pieces of each new picture of the world stick together as long as they stick with the world itself, and if not, they are rearranged, new pieces added, and the general cohesion tested.
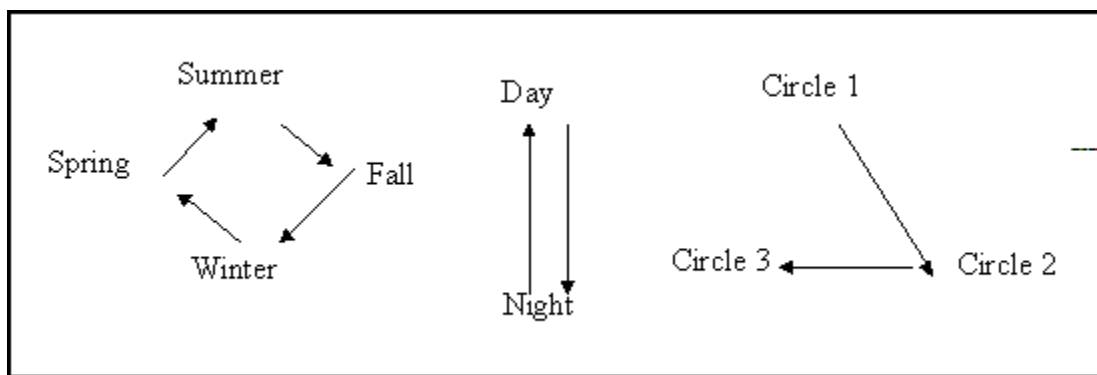
Figure 2.1. Structure of simple doctrines (compare with Figure 2.4)

One impressive regular phenomenon is the motion of the planets that was harder to describe in a convincing way than the changing seasons. Ptolemy suggested that celestial bodies were moving along perfect cycles with centers moving along other cycles centered at the earth. The Ptolemaic system of epicycles may seem clumsy and unnecessarily complicated to today's critic but at its time it was based on accepted principles of geocentric Aristotelian world, and it worked. Modified forms of Ptolemaic systems were in use in navigation long after the Copernican system had rearranged the same celestial pieces in a different way. Copernicus himself had to use a system of epicycles in his calculations. The great attraction of Ptolemaic system was that it dealt with the visible surface of the world. Only the advent of satellites and the Global Positioning System put it to honorable retirement.

Simple doctrines based on observations start from entities like summer, fall, day, night, circle, and are connected by relations schematically shown in Figure 2.1. Some of them we learn in early childhood, others have been abandoned.

A complex area of knowledge of obvious importance to everybody was medicine, where ambitious attempts were made to systematize the existing lore according to what was supposed

to be laws of reasoning. For example, Hippocrates based his understanding of illness on the balance, or rather lack of balance, between the four chief bodily fluids: blood, yellow bile, phlegm and black bile. These four cardinal humors interact, too little or too much of one causes a specific disease, and the aim of the physician is to restore the balance, for example, inducing a vomit or employing bloodletting.
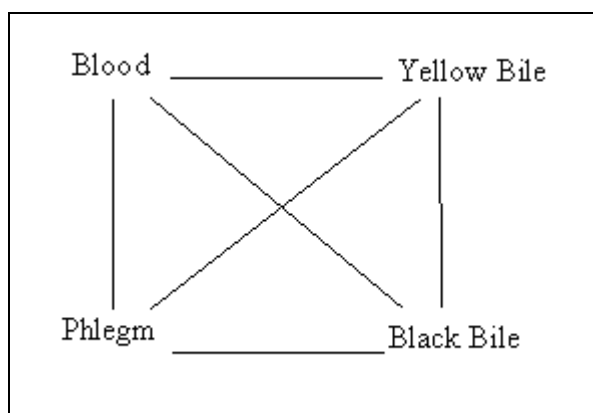

Figure 2.2. Theory of four humors

Hippocrates was not completely original here. He simply adapted the Aristotelian theory of four primal qualities—dry , wet, cold, and warm—and four elements obtained by their binary combinations: the combination of dry and cold makes earth; dry and warm makes fire; wet and warm makes air; wet and cold makes water.

We can only wonder how a doctor could succeed with such a doctrine, but Galen, the famous Roman successor of Hippocrates, used to say even more outlandish things, like "the doctor must learn to despise money."

Generations of followers of Aristotle expanded the application of his theory even further, see Figure 2.3, building a series of quartets with vertical relations in the columns.

In contemporary language, they picked up the *pattern* of Aristotle and applied it to new areas as different as seasons and human organs, considering all of them *similar*. It is the same as to say that they *transformed* the relation between the Aristotelian elements, leaving its *geometry* unchanged, but renaming the elements. Instead of any specific quartet of elements we can simply use letters A, B, C, and D or numbers 1 to 4 connected as in Figure 2.2. Note that the extended pattern now relates to the properties of the big chunk of the world: human health.

In the previous paragraph we encounter three fundamental mathematical blocks of pattern theory: *pattern, transformation*, and *similarity*. It does not look like mathematics at all, isn't it? Next, we shall add two more: *connector* and *configuration*.

We can distinguish the following components of the wider Aristotelian doctrine that make it a pattern:

1. Four building blocks with four potential links each.

2. A particular geometrical figure as *connector* of the blocks, in this case, rectangle with diagonals (or tetrahedron in 3D).

3. Rules of transformation from philosophy to seasons to humors to temperaments to organs (i.e., from one *configuration* to another), preserving the correspondence between dry/cold, earth, autumn, black bile, melancholy, and spleen and along other columns, in short, *similarity*.

4. Regularity of connection between generators: any generator is connected with any other.

Primal Qualities:

Dry/Cold   Wet/Warm   Wet/Cold   Dry/Warm

Elements:

Earth   Air   Water   Fire

Seasons:

Autumn   Spring   Winter   Summer

Humors:

Black Bile   Blood   Phlegm   Yellow Bile

Temperaments:

Melancholic Sanguine   Phlegmatic   Choleric

Principal Organs:

Spleen   Heart   Brain   Liver

Figure 2.3. Aristotelian theory of medicine

What the blocks mean is stated explicitly. But what do the relations (lines) in the diagrams signify? They also can be interpreted and named. The arrow from summer to fall and from day to night of course means that one succeeds the other in time: it is a temporal relation. The connection of one circle to another is not as clear—it means that the second circle is rolling on the first and the third on the second as in Figure 2.4, so that a point on the second circle generates a curve, an epicycle, and the three circles together perform a more complicated motion.

The lines between the humors mean something more abstract, namely that the amount of one fluid is compared to that of another. The outcome of the comparison will determine the health status of the patient.

What is important, both blocks and lines that connect them have identities of particular objects and relations between them.
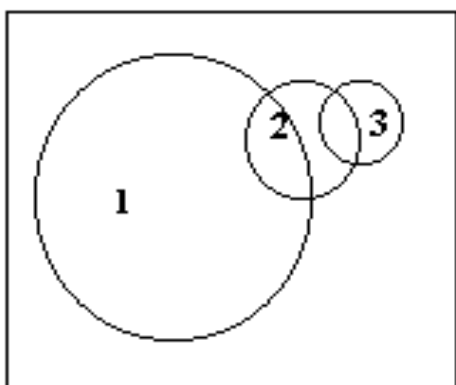

Figure 2.4. Ptholemaic doctrine

The today's weather forecast and traffic report are ephemeral pieces of information that are dead next day or even next hour. A doctrine is a more complex and long lasting representation of knowledge. We find in ancient doctrines a structure common to all systems of knowledge, and it is the structure that we are interested in.

We will use the term *doctrine* for all systems of statements about certain properties of the world, whether they are religious systems, myths, scientific theories, empirical rules, irrational beliefs, or even hearsay and advertisements. By this we want to emphasize that we do not care much about their truth value but look for a certain system of relations, i.e., structure they describe. For example, a mini-doctrine may state that brushing your teeth with a certain brand of toothpaste is good for you, while any other brand is not as good.

From the initial stages of the development of knowledge to its modern overwhelming exuberance, one thing remains unchanged. The role of the doctrine is to make a situation appear understandable by introducing a logical system, as intuitive as possible, with rules that govern

what happens. A doctrine is never a single-use disposable mental product. It is meant to be applicable to a number of situations not even known in advance. It is a pattern.

For a doctrine to be useful it is necessary that it can be applied repeatedly in circumstances that are similar but need not be identical in time, place or other incidentals. What constitute an incidental will depend upon the doctrine and its specification is indeed crucial. But if the logical system only served to explain a unique event, impossible to repeat even in principle, it could possibly be classified as a miracle but not as a doctrine in the sense we have used the term.

A reader may object that the Big Bang theory of the creation of the universe would then not qualify as a doctrine but that is not so. The Big Bang would be repeatable in principle, unless the ultimate physical laws were suspended momentarily at the time of creation and only once.

Science always gravitated toward a minimum of primitives. This principle of minimization is ascribed to William of Ockham, a logician of the fourteenth century. It has always been considered strictly intuitive and could not be reduced to other principles.

In earlier history a doctrine often became popular because of its simplicity, geometrical symmetry, and beauty, as it was the case with the Aristotelian doctrine, Ptolemean system of astronomy based on perfect cycles, the symmetry of the double predestination, and the opposition of City of God and City of Evil of St. Augustin, the pyramidal hierarchy of the Eastern Roman Empire, and the parallel between objects and ideas in Spinoza's *Ethics*.

The intuitive beauty of a scientific theory has been an ideal and a proof of superiority for scientists up to present. The development of mathematics and physics in the twentieth century seemed to confirm, however, that the goal of a complete perfection of a scientific system was illusory and any such system had small defects. Curiously, in the traditional esthetics of Japanese

art small imperfections were highly praised. So was a mole on the cheek of a beautiful girl in Islamic poetry.

The above diagrams can be said to be *representations of the knowledge* incorporated in the doctrine. Whether the knowledge represented by a diagram is true or not is another matter that will have to be decided empirically; let us leave this topic until later. For the moment let us just remark that the above representations were of pictorial nature: they used pictures to express the doctrine. This is not generally necessary. We can also employ written or spoken representations, but since most of our sensory data come to us in visual form, the diagram is an effective means of communicating knowledge, so that we shall often employ such *configuration diagrams* in the following.

The diagrams like in Ffigures 2.1 and 2.2 are actually points connected with lines. We will widely use such diagrams in this book, always with lines connecting circles, rectangles, ellipses, or just words, but the appearance of what is connected does not matter: it is just a point with a name, tag, or label.

 Epistemology, the study of knowledge and its limitations, is a time-honored field of philosophy, and often it is a good idea to go back to Aristotle to find out what he said. According to *himself,* what we know concerns only certain categories and knowledge can be represented by them. For Aristotle there were ten categories: substance, quantity, quality, relation, place, time, position, condition, action or passivity.

These ten *categories*, intended to classify the main aspects of reality, both universal and real, were used by Aristotle to criticize Plato's theory of *forms*. In Plato's view our knowledge is based on the imperfect impressions our senses give us of the world of ideals, the Platonic forms. For both philosophers, knowledge is built from such primitives by connecting them together.

This is an *atomistic* view of knowledge representation and we shall argue that such a view, generalized and modified, can serve as a starting point in our chosen task, namely to show how a road map for human knowledge can be drawn and to describe some impressions of casual travelers over the vast area called history.

When we say "atomistic," we mean not only that there are standard blocks in any knowledge representation, but also that a certain combination of the blocks is somehow held together in a stable structure, "tightly knit and bound" (Lucretius) like atoms in a molecule. The structure itself can be applied to a multitude of real or imaginary situations and it can be stretched within certain limits. It can be compared with the compass which can be used for drawing a multitude of circles, but has a certain permanency: its legs are joined with a screw, may be spread, but do not fall apart.

If one accepts this view, the next question is how should the primitives be joined together in a meaningful manner so that the resulting structure can serve as a representation of knowledge in a specified discourse. In other words what should be the glue that holds the primitives together and what should be the rules of combination? In the epicycle theory circles are the primitives and the rule says that circles roll along each other. In language, the words are the primitives and syntax is the glue.

All doctrines in the world form a superstructure, but it is so large that each individual doctrine may be as lost in the overall web as an individual molecule in a glass of water. Nevertheless, certain regularity can be clearly seen even in such a big structure best of all represented by a tree-like system of library catalogue or Internet search engine. It is regular to find cats and dogs side-by-side in a doctrine about pets, but it is irregular to find dogs and differential equations in the same topic.

In a general and more abstract context, the rules must be explicitly articulated so that we know how the combinations are *regulated*.

Regularity is yet another conceptual block of pattern theory.

To summarize, the atoms or primitives of knowledge, i.e., points of our diagrams, are connected with lines according to certain rules, so that some are connected and some are not. Thus formed *configurations* can be changed by adding new atoms, taking away others, recombining the atoms in a different order, or even changing the rules. This is a *combinatory* view of knowledge representation and it will lead us to the regularities that will be used to describe our various attempts to know the world.

The primitives are the logical objects, the building blocks, and we shall discuss in detail how they can be modified by transformations when they are viewed by an observer, a bit like when the Platonic forms are changed in the way they correspond to sensory data. Our perspective can therefore be said to be transformational. But the transformations shall be constrained to leave certain fundamentals unchanged, to allow for *invariances*, for some stability and some, perhaps very limited, degree of predictability. A cube remains a cube whether it is a solid block or a model made of twelve thin sticks. Even disorder shall be subject to laws and invariances, all the more, any natural chaos is never perfect. With all our computing power, the task of creating perfect artificial chaos remains one of the most elusive: we have to give the computer instructions how to create chaos, but instructions by definition introduce order and limit chaos. The program for a perfect chaos should be perfectly chaotic.

If the world were completely chaotic, it could not be understood in any operative sense. Science is to a large degree a search for invariances, say *patterns*, and the same is true about other human quests for knowledge although in a less rigid fashion.

This said, we should immediately apply the complementary view, stressing variability and differentiation, to allow for randomness, although only in structured forms. We will have much to say about how to do this, and it should not surprise the reader that terms like *probability and variance* will occur many times in the following. The opposition variance-invariance will serve as a *leitmotif.*

The "tightly knit and bound" structure has a high probability to exist and not to slip easily into another, more probable structure. The structure, therefore, carries some indications of its possible fate.

If we entirely neglected uncertainty and stipulated Newton's deterministic clockwork universe then we could appeal to one of the strangest creatures in the realm of Science: Laplace's Demon. This Demon is assumed to be able to observe without error the position and velocity of every atom in Newton's universe. Therefore the Demon can calculate, using the laws of Newton's mechanics, the state of the universe at any future time so that perfect prediction would be possible, for example in the stock market. The Demon could also compute backwards in time and see whether the beauty of Helen of Troy really motivated a thousand ships to be launched.

The Demon caused much headache to the natural philosophers of the 19th century—for us he should serve more as a warning against scientific *hubris.* Uncertainty plays an important role also outside quantum mechanics and should be accounted for in any theory of knowledge representation.

Laplace, contrary to his mechanistic fame, was, actually, one of the main founders of probability theory.

Thus, believing that the world can be understood and its regularities be represented by a systematic formalism we now set out to describe such a structure, *pattern theory,* a discipline

that emerged in the 1970's and has been applied to microbiological imaging, computational anatomy, automatic target recognition and other fields of quantitative nature (Grenander, 1976-1981, 1991, 1993, 19996).

The purpose of this book is to demonstrate that it is possible to use its concepts and methods also in *non-numerical* contexts. Moreover, here we attempt to use the apparatus of pattern theory to X-ray such an apparently anti-mathematical subject as history.

3.   *E pluribus unum*

The common way to proceed is to advance into the subject systematically and gradually. Pattern theory, however, is so young that some pranks can be tolerated. Let us plunge right into the middle of a historical metamorphosis, the American Revolution, where we may find not only George Washington and Thomas Jefferson, but also some major protagonists of pattern theory.

Figure 3.1 presents the Great Seal of USA, designed and made in 1782. Its motto, *e pluribus unum*, means "from many, one" and is a metaphor for the essence of the opening events of the Revolution, as well as the inscription on a penny.

In short, by 1775 there were thirteen British colonies in various degree dependent on the British Government, but in fact self-ruled, not always democratically. Some, like Rhode Island, were, actually, republics inside the Empire, others were owned by a single man, like Pennsylvania by William Penn, and some, like Virginia, belonged to the Crown. Although the colonies managed their internal affairs themselves, the British Government legislated some

issues of general importance, like taxes, trade, and new settlements, as if the "many" were actually one.
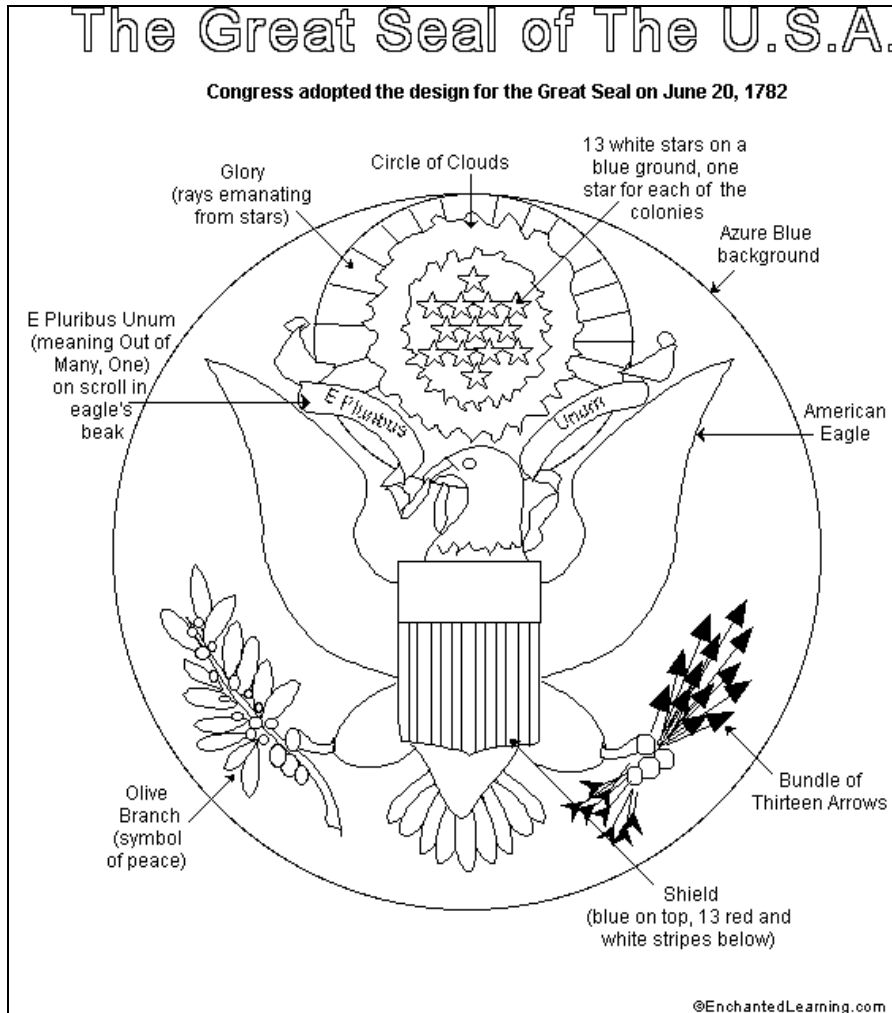

Figure 3.1. The Great Seal of the USA

When the colonies had been hurt by this policy, they formed mutual bonds, first through the Committees of Correspondence, then in the form of the Continental Congress. Next, they declared independence from Britain and, following a war, established a new entity, United States of America, with a truly revolutionary Constitution.

The chronicle of the Revolution and War comprises innumerable original documents written by the participants, secondary documents in the form of the analysis of the primary ones, and tertiary documents in form of review and analysis of the secondary ones, plus the art inspired by the events. Historians and fiction writers are capable of tracing the chain of causality and explain in most cases what event was result of what. Each such piece of research, scientific or fictional, deals with concrete place, date, location, and cast of characters.

The American Revolution called to the foreground a cohort of extraordinary and colorful personalities whose voices still reverberate in national memory. This is the live body of history, however strange it may sound when said about the long gone past.

The motto "from many, one", however, as any metaphor, works for scores of other unrelated situations such as clenching fingers into a fist, bird flocking, collecting antiques, assembling a car, calculating the bottom line of a budget, and founding the European Union. Moreover, it works for the Seal as a graphic image itself: it combines several symbolic elements conveying a set of messages: the olive branch of peace, American Eagle, thirteen arrows, emanating Glory, and the motto. The Seal is a *configuration* of generators that could be arranged in a different way.   By changing the shape and position of the components of the Seal and adding or removing some of them we would still stay within a certain *pattern*. Pattern is, in a sense, a group of configurations, but the word *group* has also a mathematical meaning to which we will return later.

In everyday speech we would say that "from many, one" (FMO) is a pattern covering a whole lot of different but in some aspect similar events. By just looking at the pattern and playing with it we may soon discover that we can change it simply by switching the words: "from one, many" (FOM). This turns out to be yet another pattern covering an even larger

collection of various things. In history we discover the dissolution of Roman, British, and Soviet empires, as well as the split of former Yugoslavia. Playing with both patterns, FMO and FOM, we may wonder whether their alternation FMO-FOM-FMO-FOM-... is also a pattern of a seductive regularity, and if we do not find it in history, it could be hiding somewhere in the future. While "many from one" still makes some sense, yet another permutation of words, "many one from" does not: it is *irregular*.

Our modest experiment suggests something that philosophers have been discussing for thousand years: there is a curious two-way relation between the world and our knowledge of it.

Some philosophers believed that our knowledge was the only primary reality, while others regarded the knowledge as secondary to the world. It all started with Plato and his mental experiment with people confined in a cave, their backs to a fire, and judging the real world by its shadows on the wall.

"From many, one" and its opposite "from one, many" are like mathematical formulas fit to infinite combinations of numbers. This is yet another metaphor, however, but how would we proceed if we tried to actually write the formula inscribed on the Great Seal in a mathematical manner? Obviously, the numbers do not matter much, but mathematics is not only about numbers. Geometry deals with points and lines, mathematical logic plays with propositions, and set theory (i.e., theory of collections of various objects), comprises everything we can imagine.

For a beginning, we can simply write: **many $\Rightarrow$ one**, but it is just a symbolic shorthand for the phrase. In mathematics one is one and two is many. If we portray "many" by more than one objects, for example, dots, we can write:

$$\begin{matrix} \bullet & \\ & \bullet \\ \bullet & \end{matrix} \quad \Rightarrow \quad \bullet$$
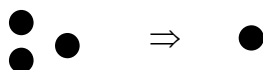
Here three identical objects turn into one, but this is not what happened according to the verbal formula because none if the initial objects disappeared. To correct this distortion, we have to label the dots to show that they are distinct.

$$\begin{matrix} \bullet 1 \\ \bullet 2 \; \bullet 3 \end{matrix} \quad \Rightarrow \quad \bullet 4$$
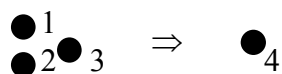
This, again, is not quite satisfactory: the original colonies were the same before and after the radical change, with same land, people, and cattle. Yet their identity is completely lost in our symbolism. In fact, the colonies made a new entity without losing their old identities, see Figure 3.2A.

The historical transition started with the formation of bonds between the colonies. This is not just metaphor but a political term. Bond is a binary relation, it requires two participants, and a line connecting two dots is a convenient, although not the only one, way to graphically represent a binary link.

The bonds turned out to be strong enough for the colonies to act as a whole (large circle) on some issues, for example, on foreign and military policy. The union was able to form bonds with other countries on equal basis, see Figure 3.2B.

The bonds have identity, too, which we tried to portray graphically. In terms of diplomacy, the two-arrow line means negative relation, while simple line signifies a positive one, i.e., mutual gravitation. At the moment, there was a historical mutual distrust and rivalry between Britain and France, which contributed to the attraction between France and USA. Remarkably, the bonds between Britain and USA have been friendly after the peace treaty up to present. The

relationship with the other continental neighbor, Spain, was complex and mostly antagonistic.

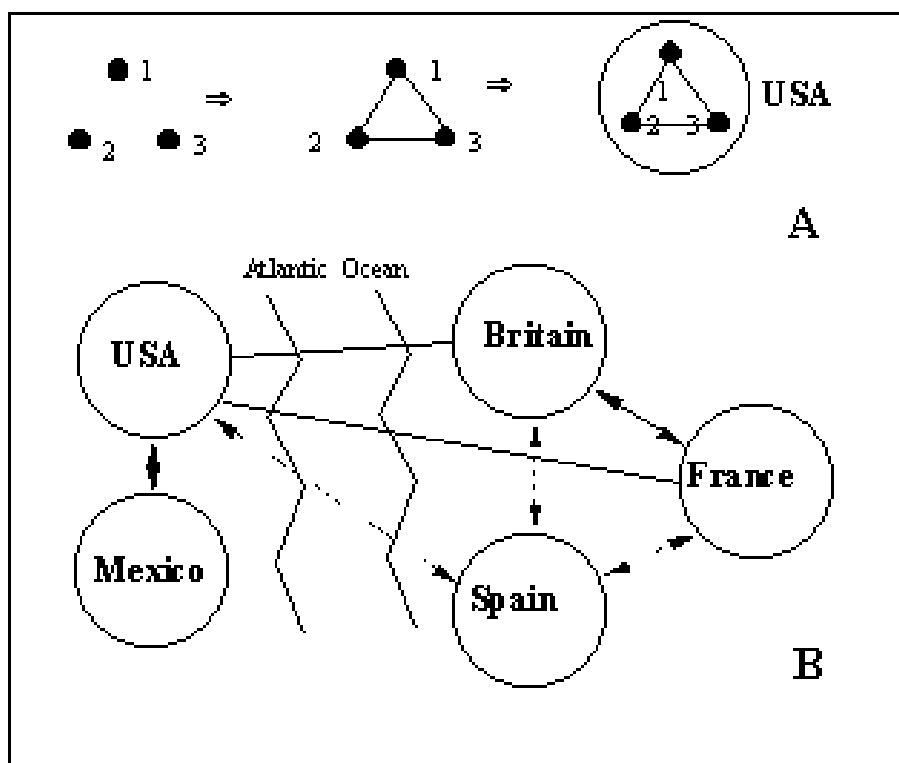For Spain and USA a conflict was in the cards.

Figure 3.2. The Union and its external links

We do not want to go into the particulars of the relationships between Spain and other European denizens, but by no means they were friendly, and for that matter hardly any relations in Europe were.

There are several ways to form a union. Concerning this subject, Crane Brinton wrote a book appropriately entitled *From Many One*. Half a century before the event, it predicted the formation of the European Union. Crane Brinton analyzed the situation when several sovereign entities give up their sovereignty to form a union.

There is the process in which a single unit conquers or tricks other units into defeat and absorption; thus unit A will swallow units B. C, D, and so on to produce a greater unit A. This I shall call the method of imperialism. And there is the process by which a number of units get together voluntarily and agree to merge themselves in a larger whole; thus A, B. C, and D will unite to form E. This I shall call the method of federalism. Now imperialism and federalism are in these senses mere abstract polar concepts, useful to us in ordering our thought, but by no means accurate descriptions of how political units do get integrated. Pure force or pure consent, pure imperialism or pure federalism, simply do not exist on this planet. The conqueror always finds among the conquered some who had been won to his cause in advance. To use the language of our own times, there have always been quislings. Nor does the best of federal unions evolve from unanimous consent and without frustrations. It would clearly be an exaggeration to say that when at long last the State of Rhode Island and Providence Plantations deigned to join our federal union force was required to bring her in; but I think we can say that at least force of circumstances was necessary to that end (Brinton, 1971, p.20).

These two types are illustrated in figure 3.3. The United States were formed, without losing identity of the federates.

When an empire formed by absorption splits, it rarely returns to its original constituents, as the fate of Austria-Hungary can illustrate. The Soviet Union, formally a federation, had always been closer to an empire in its power structure. When it split in 1991, the important Crimean Peninsula was lost because in 1956, when nobody could imagine the future, it had been transferred to the administrative jurisdiction of Ukraine

If the US ever splits, we can only speculate whether it will happen along the interstate lines. Can it ever happen? No one but the collectors of historical patterns can imagine that. History, however, often beats imagination.

In fact, there could be more subtle structural differences in the pattern of unification. Some of the types are shown in Figure 3.4. It can be a cooperation of several equals with one single selected entity, union of equals, hierarchy of domination, and union of the unequal, as well

as a lot of combinations, most of them not yet explored in the course of history but more viable in economic relations.

To the structural variety of unification we have to add much finer quantitative differences.

To explain the whole process, Crane Brinton chooses to approach the problem in terms of emotions, which seems diametrically opposite of what we intend:

> What we are concerned with here is the process by which once "independent" or "sovereign" states yield, voluntarily or involuntarily, that independence or sovereignty to some other political grouping. Yet since the word "sovereignty" is a notably complex word, charged with centuries of debates among political philosophers, and since the process as above outlined sounds a bit mechanical, I should like to translate it into the language of human emotions.
>
> About 1100 A.D., for instance, it was sweet and fitting for a man from Normandy to die and kill for his duke, and for a man from Paris to die and kill for his king. Subinfeudation may have confused many good men in this matter of ultimate loyalties, but they all thought the ultimate loyalty could somehow be found on earth.
>
> Within a few centuries, Normandy became, as we say coldly in the textbooks, a part of France; Normans became Frenchmen, and no longer legally killed Frenchmen. What is true of Normandy eventually became true of Brittany, Flanders, Languedoc, Vauphine, and all the rest of what now seems to some of us *la France eternelle* (Brinton, 1971).

This quotation, however, can be rewritten in a symbolic form using different types of emotional bonds: positive and negative:

$$\text{Parisian} \longleftrightarrow \text{Normandian} \Rightarrow \quad \text{Parisian} \text{———} \text{Normandian}$$
$$\text{(repulsion)} \qquad\qquad\qquad \text{(attraction or indifference)}$$

There is something about emotions that could significantly flavor our dry dot-and-line presentation.

Like birth and death, typical for the phenomena of life, attraction and repulsion in the forms varying from pursuing a pray and fear of predator to patriotic love of the neighbor and hate of the invader penetrates all levels. Answering the question "why do they hate us," we can only point to the persistent historical pattern. There is some "physics" behind the hate, too: the collective hate of common enemy, real or imaginary, strengthens the internal cohesion, as in the separation of oil and water.

Regardless of international relations, it is hard to build any meaningful social structure without recurring to forces of opposite sign. That observation stimulated the development of structuralism in studies of culture, especially, anthropology.

As modern history and current events confirm daily, a redrawing of the map commonly leaves an area with a lot of bad blood between inhabitants, prompting further conflicts and wars in which the sides look for ideological friends and relatives.

It looks like the mathematics of history is closer to geometry than to calculus. In fact, our dots are nothing but points because their shape and size does not matter. We give them various names, but there are no nameless points in geometry, either. Unlike geometry, however, we are not concerned with the length, angle, and distance. The more abstract world of binary relationships is called *topology*, formally, a branch of geometry.
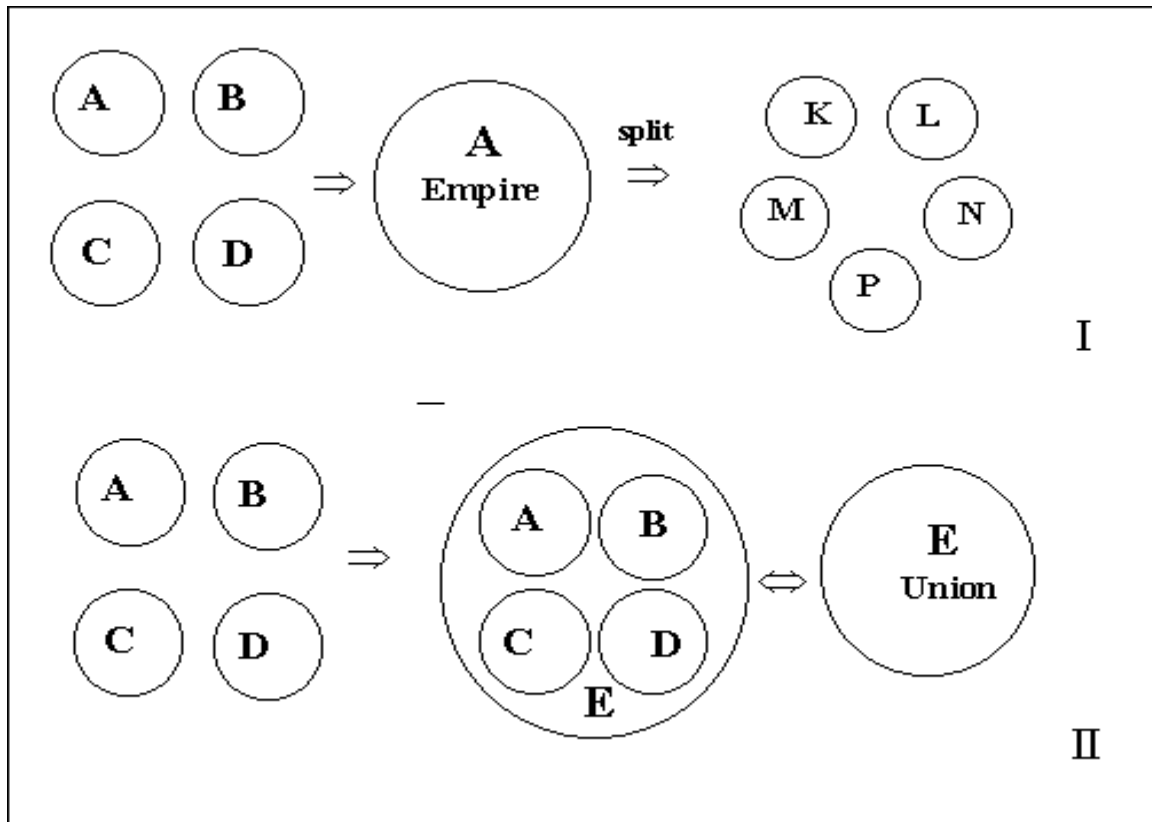
Figure 3.3. Imperialism (I) and federalism (II)

While all points in geometry are identical, except for their positions, our points can be very much different without having anything to do with their position in space. They can form various bonds, can carry some labels and even have a fine structure of their own. Let us further explore this direction.

We can supply the line between the two objects of mutual emotions not only with a sign but also with an indicator of intensity. The line, therefore, will have something of a length, bringing it even closer to the Euclidean geometry.
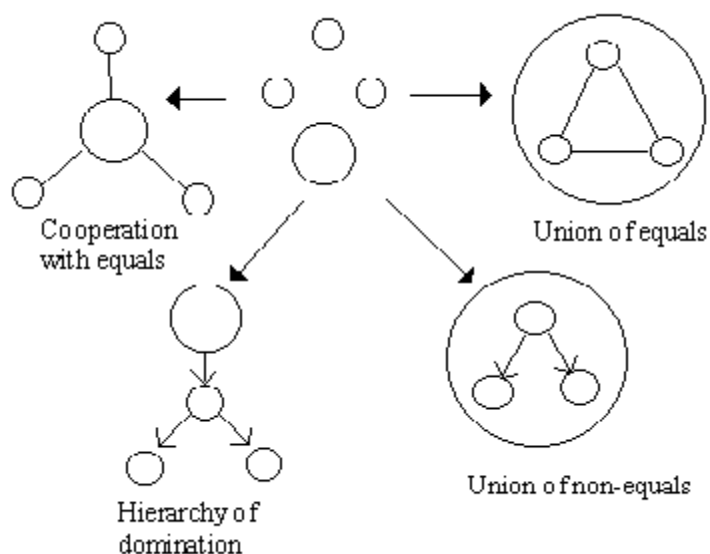
Cooperation
with equals

Union of equals

Hierarchy of
domination

Union of non-equals

Figure 3.4. Types of unification

To mark the range of attraction and repulsion, we can set up a more detailed symbolism,

for example:

$$a \text{—♥—} b \Rightarrow a ==== b \Rightarrow a \text{——} b \Rightarrow a \cdots b \Rightarrow a \longleftrightarrow b \Rightarrow$$
  love   strong attraction   attraction   indifference   repulsion

$$a \rightarrowtail\leftarrow b \Rightarrow a \rightarrow\leftarrow b \Rightarrow a \longrightarrow b \Rightarrow \quad a$$
  struggle   war   domination   elimination

We can also quantify it with a single line and a value on a scale, say, from -5 to 5. This is

something we should take a note of. Line is an all-or-nothing binary relation that is either there

or absent. Line with a quantifier, whether by a number or just by words "much" and "little" or

"strong" and "weak" is a different mathematical object. With all its simplicity, it gives an access

to describing objects of great complexity and realism.

In chemistry, a bond between two atoms carries an invisible number, to be found in

handbooks, which characterizes its strength (energy). The strength alone does not mean

invincibility. Very strong bonds are commonly attacked and broken in chemical reactions by

tricks reminding of the Trojan Horse. Love, politics, and economics are pattern relatives of chemistry, some examples to be soon presented.

As same meaning can be expressed in various languages and styles within the same language, there is no single way of portraying the type of bond between two entities, although the meaning remains the same.

As the next step toward graphics of history, let us try to draw a *mechanism* of the entire American Revolution, Figure 3.5.

We use small circles as symbols of pre-revolutionary colonies and subsequent states, limiting their number to three just to save space. We will use large circles for such entities as Parliament of Britain (B), Continental Congress (CC) and the national US Congress (USC) that took over. We do not claim allegiance to exact detail, and our description should be regarded rather as related to events on a planet very much *similar* to our Earth and during a historically similar period, but not exactly same. To learn how the Revolution actually happened, one should turn to books of historians. To learn how everything can happen and what everything is ... well, let us wait until Chapter 15. *The invisible Walls of Events*.

Everybody understands what it means to be exact. What *similarity* means is a topic for a separate discussion.

The pattern of the American revolutionary transformation displays between the initial state **K** and the final state **Q**. History is a continuous process and of course the terms *initial* and *final* correspond only to a certain segment of the process.

The initial state **K** is the array of disjoint colonies dominated by Britain. The relationship of domination is   one-way and is shown by arrows. In the state **L** the colonies form mutual bonds. Next, in **M** they develop a common legislating and coordinating body, the Continental

Congress. The tug of war between the Crown and the Congress ensues (**N**). The union strengthens while the bonds with the Crown turn at **P** into hostilities and war (⟵⟶), and finally dissolve (**Q**).
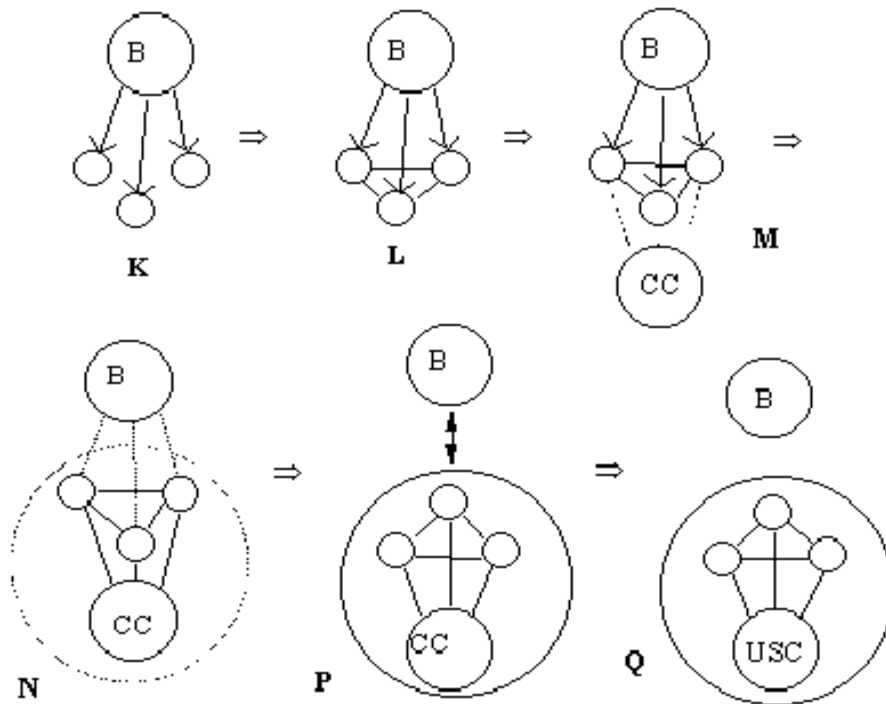

Figure 3-5. From domination to independence

The entire *pattern* **K** possesses a high generality. Here is a short list of some possible initial situations with the same pattern of change.

1. A similar colonial situation on another planet.

2. A fleet of spaceships under the command of the stellar federation.

3. Former colonial rule of France in Northern Africa.

4. A crew of workers under command of their leader.

5. Patriarchal family where everybody directly obeys a single person.

In our simplified presentation of the American Revolution we use only three small circles for the initial colonies, but we could use ten or thirteen, the *pattern* would not change. It would be the same for a crew or a fleet.

Some natural questions arise:

1. Why were the bonds between the colonies and Britain broken?

2. Did the dissolution of the colonial bond follow or precede the formation of the federal bond?

3. Why was the transition irreversible?

4. Did the bonds change one by one or all at once?

5. Within the same initial pattern **K**, what was the historical difference between the liberation of French and British colonies?

6. What are the alternative routes from pattern **K**?

7. Can pattern **Q** fail and run the reverse course toward **K**? Can we make many of one?

8. Why do we need to use points and lines instead of words or letters?

If we substituted symbols for the words Britain, British, French, and colonies, nobody could guess that the subject was history. We use here the terminology of our point-and-line pictures and, hopefully, this language does not sound completely alien. Note also, that the pictures themselves do not provide a clue to the answers. Intuitively, we can guess that the

answers would have something to do with the strength or other properties of the bonds, some of which are broken and other established.

Our questions may rise new questions of epistemological nature, i.e., questions about asking questions. For example, how can we ask "why" regarding history? This question does not make sense unless we have something like the laws of nature for human society. If all history is unique and non-repeatable, how can we even think about any alternative routs? No wonder, history is a fertile soil for all kinds of arguments and antique theories.

At this point we are asking more questions than we can answer, but a good question is half an answer. Although history never repeats literally, we can clearly see some patterns. If we focus on the reign of Henry VIII, with all his extravagances and unfortunate wives, there is little we can learn about world history. We learn much more about monarchy when we rise above some details and we learn even more about history when we follow the rise and decline of European monarchy from the early Middle Ages to its demise in the national revolutions.

We have to stay at a certain level above the detailed historical narrative, to be on target.

The confusion between unavoidable explanation and indispensable narrative is closely connected with another equally natural terminological confusion between generalizing and theorizing. Every story-teller generalizes. He narrates occurrences, i.e. things that have happened. But the plainest occurrence is really a series of simpler occurrences. Napoleon lost the battle of Waterloo: what a collection of occurrences, psychological, ballistical, tactical, strategical, logistical, is summarized in this generalization! "The company director lit a cigar." This implies that he helped himself to a cigar, bit off the tip, or cut it off, or merely punched it; he struck a match (or a lighter) or somebody offered him a light; he puffed several times, and uttered a little sigh of pleasure as he took out the cigar and looked at its farther end; meanwhile, he expelled several distinct clouds of smoke. The narrative would never reach its end if it had to enter into these details, every single one of which can in turn be analyzed into further details. On a larger scale we can say: "The early Georges made use of their position as kings of Great Britain to further their ambitions as electors

of Hanover." This generalization is still a statement of fact. It is neither the formulation of a "law" nor the expression of a philosophy of life (Renier, 1965, p.23).

Thus, step by step, from however magnificent and influential but still limited in time and space American Revolution we, hopefully, have come closer to the major questions of global history: why history is how we know it, what could have happened on Earth otherwise, and why it did not. We can ask ourselves even more daring questions: what in principle can happen next year and next century, what is most likely to happen, and what we can do to enhance some directions and suppress others.

What we are probing here is a symmetrization of history to cover not only the past but also the future. Doesn't it seem that in a fit of megalomania we imagine ourselves if not Napoleons? then Aristotles? or St.Augustins? who built doctrines out of the sense of symmetry? To be on the safe side, we use the question marks like an excessive postage.

We can certainly ask those maniacal questions, but the answers would not help us. Making history always takes at least two interacting sides, for example, "us" and "them," and the outcome of every such struggle is rarely predictable. We should have in mind that what is good for us may not be good for others, and if we all had this perfect understanding of global social evolution "they," the others, could still turn the tables against "us."

History, running as we speak, still retains some characteristics of a sports game where everybody plays by the same rules but, nevertheless, only one side wins. Unlike the game of football or chess, however, nations and their leaders can also play by the rules of their own. The victory is never granted. Like individuals, to play the uncertain game of life, nations need some basic optimism more than the algorithms for politics,.

The aim of this chapter was to make another step toward a symbolic language that hides the differences between events separated in time and space but brings to the foreground the similarities. We do that by describing the structural aspects of events in terms of variously labeled points and connecting lines. Those are our Platonic shadows of the colorful and vibrant reality, and we are ready to experiment with them and give them a gift of life of their own.

Next, we would like to extract some regularity from the complex and confusing picture. Inventing a new philosophy of history would be no better than any other philosophy. Instead, we would like to show that the chosen way to treat historical transformations brings them in a much wider family of natural and artificial phenomena, which all could be treated the same way.

But do we really need it? How confused is history?

4. Alternatives and altercations

In this Chapter we are looking for evidence of confusion, uncertainty, and excessive imagination in history. In order to prove that we are not driven by arrogance or critical itch, we need first to gather some factual and counterfactual material.

For most of us, non-historians, the French Revolution is mainly what is written about it two centuries later. The text is the ultimate source of our lay knowledge about the event. Textbooks and other historical narratives describe the Revolution in terms of social and economical condition, fate of a leader, movement of a group, military campaign, massive human loss, rearrangement of social roles and interactions, and extraordinary event.

Studying the texts, we immediately find out that the narratives by different authors can be different and even contradictory. The distance in time does not explain it because even the contemporary observers and participants, for example, Robespierre and Marie-Antoinette, could have very different perceptions.

The famous example is the dispute between Edmund Burke, an Englishman, and Thomas Paine, an American, who both observed the French Revolution but evaluated it in opposite terms. Remarkably, both were cherished by subsequent generations for their insight and even published under the same cover (Burke, 1973).

The French historians—more than anybody else—had a lot of arguments about their own history.

Among recent historians, Francois Furet wrote at length against politicizing the French Revolution. He noted that every historian in France carried a label of royalist, liberal, Jacobin, anarchist, or libertarian. The history of the Revolution could not be objective because "The Revolution does not simply 'explain' our contemporary history; it *is* our contemporary history," "...the Revolution has a birth but no end" (Furet, 1981).

No wonder, historians disagree. Had it been otherwise, there would be one historian laureate for all humankind at any given time.

Very few things in the world cannot be subject to hair splitting. We all have a complete and absolute record on Hamlet from the Shakespeare's text, but scores of interpretations of Hamlet's character have been accumulated until present, with no end in sight.

All contemporaries and historians consider Louis XVI weak, but maybe he was just too human to be the king.

Louis XVI (1774-1793) was a dull, ill-educated monarch, and he had the misfortune to be married to a silly and extravagant woman, Marie-Antoinette, the sister of the Austrian emperor (Wells, 1920, p. 709).

Louis XVI (1774-1792), unlike his grandfather, was earnest and pious. Though fat and clumsy, he developed real skill at his favorite pastimes of hunting and locksmithing. But he had a slow mind and was both irresolute and stubborn (Brinton, 1967, Vol.2, p. 96) .

Note the difference even in the dates of the end of the reign of Louis XVI in the two above quotation: in 1792 monarchy was abolished, and in 1793 the former King was executed.

Charles H. George was of a better opinion about the government of Louis XVI:

In fact, King Louis XVI and his ministers showed rather extraordinary daring and political imagination once Calonne had made the shocking discovery of the size and character of the national debt (George, 1962, p. 347).

Considering *Hamlet*, at least the text of the play is a firm ground on which multiple interpretations can be built. In case of history, the ground is less solid. Conflicting opinions may clash even around facts, not just interpretations.

When Robespierre, a day before his death, was under arrest and his supporters attempted to free him,

... his troops, discouraged by lack of action—perhaps also by a downpour of rain, though there is actually some doubt as to whether it rained or not—were melting away rapidly (Brinton, 1966) .

Was it raining or not?

"The famous battle of Valmy was no battle at all" (Brinton, 1966). Was it?

Moreover, " There has never been a French Revolution" (de Gramont, 1969, p. 114).

That would be certainly an extreme statement, but wait, the next sentence explains:

There has never been a forcible overthrow of an existing French political system in which the new regime succeeded in maintaining itself or the values for which it fought. Revolutions were always confiscated, their principles denied or diluted. They were always the agents through which an authoritarian, centralizing regime seized power. In France, wars are greater agents of social change than revolutions (*ibid*.).

There was some doubt even about whether Napoleon was born in 1768 instead of 1769. The year of 1768 would mean that he was not born a Frenchman because it had been before Corsica became part of France. But even if he was formally born a French citizen, he spoke French with an accent.

Is history a collection of opinions or facts?

The most common problems with facts are that there are too few or too many of them. If the latter is the case, any historian who writes about a subject has to perform a selection because of the limits of space. Facts get lost each time a new compilation is written. Facts and opinions compete for the space of the page like the rainforest plants for sunlight. As result, a vertical hierarchy of facts develops, and only the top facts see the full light of the day.

Three or four hundred years ago to study history meant to read Plutarch who on many pages described the life of Scythians in fascinating detail. Today the Scythians get maybe a dozen lines in a textbook..

The following classical story was often mentioned in history textbooks as an example of ambiguity of oracles. When Lydian king Croesus asked the Delphic oracle whether he should march on the Persians, the answer was that he would destroy a mighty empire. Croesus felt encouraged to march, only to learn later that the empire to be destroyed was his own.

This story came from Herodotus (1955), who had told much more on the subject than later entered the textbooks. Herodotus provides a wealth of detail. The cautious Croesus consulted the Pythoness again, asking whether his kingdom would be of long duration. The answer was that it would, at least till "a mule is a monarch of Media." It turned out later that the mule the oracle meant was Persian king Cyrus who was of a mixed descent, from Median mother and Persian father.

The story of the unhappy fortune-telling goes for pages, with many quotations of the oracles. Naturally, all that has been lost in modern books, and for good reason. A lot of what we find in Herodotus looks like pure fiction inspired not by Clio but by Calliope.

To us this esoteric subject seems to be of no relation to history as we understand it today. We mention it as an introduction into the topic of prediction, to be revisited in Chapter 27, *History and Computers*.

We can only guess how much of the material has been lost with every new quasi-Orwellian repackaging.

To take a more modern example, if our posterity decided to study US history by video recordings of TV morning news, history would show as much relevant factual flesh as a fishing net could hide.

The art of history is, like any art, selection: working on large-scale topics, historians select a limited number of facts and interpretations from a large amount of available material and they may do it by different criteria such as belief, tradition, intuition, personal idiosyncrasies, sense of mission, nostalgia, entertainment, political arguments, accuracy, commercialism, spirit of contradiction, or just the mere page space. Similarly, a writer selects a fixed and limited sequence of words from a practically infinite stock of meaningful combinations.

At the same time, history seems to be enriched in a curious way.

Last November, a group of counterfactualists convened at Ohio State University to make the case that the understanding of history can be greatly enhanced by changing one significant fact and examining other outcomes. In the words of Philip E. Tetlock, a professor of psychology at Ohio State who helped organize the conference, this underscores the notion that there are few inevitabilities in history and leads to "a more sophisticated appreciation of causation" (Honan, 1998).

Here are some examples of counterfactual questions: What if Britain had stayed out of the First World War? What if Germany had won the Second? What if the Soviet Union had won the Third? What if there had been no American Revolution? What if the Cold War had been avoided? What if Communism had not collapsed?

Niall Ferguson answers the first question the following way.

Had Britain stood aside—even for a matter of weeks—continental Europe could therefore have been transformed into something not wholly unlike the European Union we know today—but without the massive contraction in British overseas power entailed by the fighting of two world wars. Perhaps too the complete collapse of Russia into the horrors of civil war and Bolshevism might have been averted. Though there would still have been formidable problems of rural and urban unrest, a properly constitutional monarchy (following Nicholas II's probably inevitable abdication) or a parliamentary republic would have stood more chance of success after a shorter war. And there plainly would not have been that great incursion of American financial and military power into European affairs which effectively marked the end of British financial predominance in the world (Ferguson, 1999, p. 460).

This passage is a good illustration of what probability is. There is a sequence of ten events that might have or might have not happened. Britain might have stood aside but it did not.

Suppose the *a priory* probability of that was 0.5 and so were the probabilities of all the other nine events on the condition that the previous events in the chain had happened. Then the probability of the complete scenario starting with the Britain's standing aside would be $0.5^{10} = 0.001$. If we take the probabilities as 0.2, the ultimate probability will be one in ten millions. Of course, this calculation is flawed because the outcomes are not independent, but it shows how improbable every extended scenario could be.

Was the American Revolution inevitable? What could happen otherwise? Is there any determinism in history? At the first glance, whether we describe the American Revolution verbally or in point-and-line symbolism, it matters little, if at all, regarding these questions. The question "*what if* Germany had won WWII?" bears little relevance on the question "*why* USA had won the Cold War?" or even "*did* USA actually won the Cold War?" because we assume that the events underlying the question about the Cold War did happen regardless of our interpretation.

The counterfactual thinking, however, is not just a postmodern fad. It has always been typical for historians of the past and we can find innumerable examples. Here are some.

> If they [Hellenes] had brought plenty of supplies with them, and had persevered in the war without scattering for piracy and agriculture, they would have easily defeated the Trojans in the field, since they could hold their own against them with the division on service. In short, if they had stuck to the siege, the capture of Troy would have cost them less time and less trouble (Thucydides, 1955, p.352).

> If all the Barbarian conquerors had been annihilated in the same hour, their total destruction would not have restored the empire of the West: and if Rome still survived, she survived the loss of freedom, of virtue, and of honor (Gibbon, 1946).

It is rather typical for some historians of the French Revolution to indicate that the revolution might have taken a different, less violent course if the king was more decisive, or if he accepted the programs of his successive directors of finances Turgot, Necker, and de Calonne, or if in the very beginning he took the side of bourgeoisie and the masses for whom he had been the Good King.

The things could be different if De Launay, the governor of the Bastille, did not lose his head and order to fire on the group of militia who came to ask him for gunpowder. When he had finally decided to surrender, it was too late. De Launay, therefore, lost his head twice.

Napoleon could have won the battle of Waterloo if he was not physically exhausted, or, according to Duke of Wellington, did not use his usual well known tactics (pattern, we would say) of head-on assault.

There are scores of such "ifs" in our personal stories. As Graham Green put it in *The Comedians*, "There is a point of no return unremarked at the time in most lives," (G.Greene, 1966). We are left only with a "what if" after that point.

> As it turned out, Louis had many opportunities in the next years to retain important powers for himself as a constitutional monarch. But his vacillation and feebleness were in the end to cost him both his and his wife's lives, and turn the Revolution itself into paths that it need never have taken if Louis, recognizing the signs of the times, had contented himself with a position not unlike that of his brother monarch in England" (Easton, 1977).

> Suspected by both sides, Mirabeau dragged out the last few months of his life in a pretty complete political impotence. His fate suggests the limitations, during so unusual a time as that of the French Revolution, of even extraordinary political sagacity. Had his [Mirabeau] moral reputation been better, had his king been more intelligent and more determined, had Lafayette and a few others been willing to cooperate, and had he lived, Mirabeau might have saved France from the madness of the Terror (Brinton, 1963).

Had Louis been willing to turn Voltairean as regards the church, to accept the position of first *citizen* of a land of equals, to repudiate his family and his friends, had he, in short, turned Jacobin, the Jacobins might have accepted the monarchy. (*ibid*.)

Just as the rapid growth of coke-fueled blast furnaces in the eleventh century leads someone attuned to European history to suppose that an industrial revolution of general significance ought to have followed, so the overseas empire China had created by the early fifteenth century impels a westerner to think of what might have been if the Chinese had chosen to push their explorations still further. A Chinese Columbus might well have discovered the west coast of America half a century before the real Columbus blundered into Hispaniola in his vain search for Cathay" (McNeil, 1982, p.45).

The role of accident in history was sometimes exaggerated:

Cleopatra's nose: had it been shorter, the whole aspect of the world would have been altered (Pascal, 1995) .

Even Pascal's native language reveals a historical link. In French, *aléatoire* (random, probabilistic, stochastic) is a curious repercussion of the historical dictum of Julius Cesar at crossing the Rubicon: *alea jacta est*, the die is cast.

In sci-fi stories, the time-travelers into the past inflict catastrophic changes in the future by a minute action. In fact, history tells us how difficult it is to change the course of history in the long run. And yet the role of random events in the short run is beyond doubt.

What could happen to the world if Lord Halifax, and not Churchill, disliked by the establishment, were the prime minister in May, 1940?

The victorious Wellington said after the Waterloo that that was a "damn

close run thing." The battle was full of errors on both sides and if not for the timely appearance of Blücher's army it could be lost by the coalition.

With a tortuous twist of mathematics, probability was even used as a political weapon, and for Stalin's henchmen, it was no coincidence that the "traitor" Leon Trotsky happened to be in Berlin when other enemies of the people were there.

We are not historians and we have had no chance to acquire even a small part of the knowledge a historian possesses. Not being historians, we cannot repeat their work and we have to choose a limited number of sources among the incredible abundance.

Finally the time has come to explain why, contrary to what the reader might have expected, we are highly sympathetic to counterfactual history in spite of its improbable conclusions.

The counterfactual experiments may seem just a mind game, but a chemist would easily find a kindred spirit in a counterfactual historian.

When a chemist explains why a chemical reaction takes the observable turn, the explanation consists in making up the list of all other possible directions, comparing them, and showing that the observed one had some advantages over the rest. The advantage is expressed in terms of probability. The chemist builds a tree of alternative outcomes and let them compete—in his mind or, more often today, in a computer—for the highest probability

Some pharmaceuticals require ten and more steps of the synthesis. Suppose that the yield, i.e., the percentage of desired molecules among byproducts and non-reacted starting material is 50% at each stage. The final yield after ten stages will be 0.00001 %. Even if it was 80%, the total would amount to 0.001%. However improbable, the chosen sequence of chemical events may be incomparably more probable than other pathways to the product. Besides, the chemist

possesses some tools and tricks of the trade for pushing the process in the desired direction, very much like a skilled politician running the election campaign.

The formulas of organic chemistry look conspicuously like points connected with lines. The formula of common aspirin is an example (Figure 4.1). The same structural meaning is expressed in different symbolic languages. Figure 4.1A is the more redundant version of the more standard 4.1B, which is the common abridged way of writing chemical formulas.
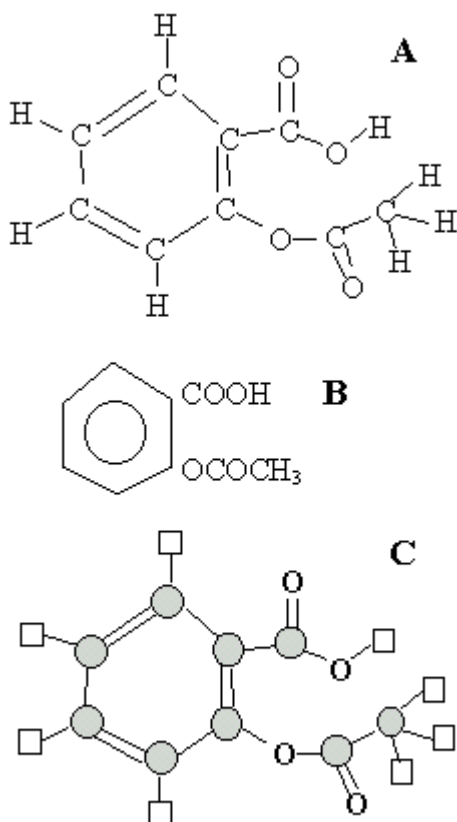
Figure 4.1. Different ways to portray structure of aspirin

The system of symbols in Figure 4.1C was invented here solely for the purpose of illustration. The two structures, A and C, have differently looking points but the same
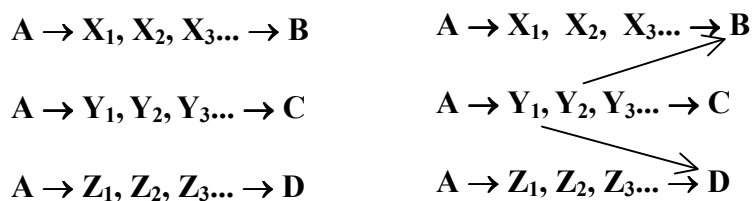
connecting lines. They are interchangeable without the loss of structural information, so that a Terrestrial chemist would understand a Martian chemist whether the latter wrote either formula A or C, and, probably, even B.

The way chemistry explains how compound **A** turns into compounds **B** (no relation to Figure 4.1) involves some virtual thinking of the "what if" sort. The chemist tries to imagine all possible intermediate structures **X** between **A** and **B** and then ranks them according to some criteria, from least probable to most probable.

$$A \rightarrow X_1, X_2, X_3... \rightarrow B$$
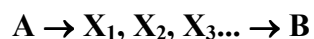
The common criterion is energy, which metaphorically and poetically can be presented to hard line non-chemists as tension, discomfort, or frustration of the molecule. The least "frustrated" **X** (as well as most "rewarded") is the most probable.

A similar way of thinking is involved in answering the question why A turns into B at certain conditions. The chemist tries to imagine all other virtual outcomes **C, D, E** ... etc., and ranks them by probability. For each couple **A →B, A→C, A→D**..., the chemist builds the intermediate states and ranks them again, to arrive at the final conclusion, which is always probabilistic.

$$A \rightarrow X_1, X_2, X_3... \rightarrow B$$
$$A \rightarrow Y_1, Y_2, Y_3... \rightarrow C$$
$$A \rightarrow Z_1, Z_2, Z_3... \rightarrow D$$

$$A \rightarrow X_1, X_2, X_3... \rightarrow B$$
$$A \rightarrow Y_1, Y_2, Y_3... \rightarrow C$$
$$A \rightarrow Z_1, Z_2, Z_3... \rightarrow D$$

Different final states can have the same transition state, which complicates the picture even more.

Comparing all the pathways branching out from A, the chemist may come to a certain conclusion, *post factum* as explanation or *a priori* as prediction. For example, **C** and **D** could be highly improbable and only **B** was to be expected, or, **C** and **D** could be expected with ratio 2 : 3, etc.

The question we could ask at this point is whether **A, X, Y, Z, B, C**, and **D** could be something other than chemical structures. Remembering the invocation of rain by sprinkling water, we may try social structures and situations within the same framework of the diverging transition and final states. It is the same branching tree of outcomes that we find in counterfactual history.

The question how chemistry can not only be possible at all but also very successfully navigate in such complexity—as it certainly can—exceeds the scope of this book. Our secret desire is to make chemists and historians look at each other with a new kind of curiosity and sympathy.

In chemistry, where a large number of molecules can take part in all possible transformations, the outcome is a mixture of all possible products. Some of them are so improbable that they cannot be detected. Society, on the contrary, exists in a single copy and only one transition really happens. For comparison, when an individual makes a decision, only one action can take place, but the alternatives are repeatedly replayed in mind, see *Hamlet* , the classical treatise on human chemistry.

This is one of the basic ideas of this book. If we add to the above that chemical structure is also visualized by points and lines, our rain dance may seem something more than an extravagant act of entertainment.

The entire problem, therefore, amounts to two sub-problems:

1. Formal presentation of historical knowledge in terms of "atoms" and bonds between them.

2. Formulation of criteria of choice between various structures, i.e. what makes some structures more *probable* than others.

Throughout centuries, historians and philosophers gave over two hundred reasons for the fall of the Roman empire. David Gress classifies them all along the following six types: religious, socio-economic, environmental, managerial, cultural, external (Gress, 1998). The reader can offer his or her own solution of this historical counterpart of Fermat's Last Theorem in mathematics. A conciliatory chemist would wisely say that all those reasons, and probably more, contributed to the outcome, each with its own weight in the total, some significantly, some little.

The parallel between natural sciences and history is nothing new. Compare the following reasoning by Nicholas S. Timasheff:

The final formula of the causation of a revolution is this:

If, within a state, a tension (or a cluster of tensions) has arisen between the government and an opposition and has reached such proportions that the symptoms of plasticity have becomes apparent, and if the conflict has not been resolved either by reform or reaction, a revolution is most likely to follow (Timasheff, 1965; author's italics).

Here the explanation uses a physical model: the parameter of the transition state from peace to revolt is tension, and when it exceeds the plasticity limit and reaches the breaking point, a change of structure follows.

While discussion of humanities in terms of natural sciences has been often looked askance upon by many on both sides, there are more and more proponents of the admission that what yesterday was regarded as metaphor turns out to be analogy today, and could be a statement of science tomorrow. One of the founding fathers of the new thinking has been Ilya Prigogine who thus defined the common ground for nature and history:

> We are now approaching he end of the twentieth century and it seems that some more *universal message* is carried by science, a message that concerns the interaction of man and nature as well as of man with man (Prigogine, 1984, p. 6).

A vague parallel between chemistry and history in terms of points and lines, almost a metaphor, was for many years a guiding idea for the author-chemist of this book. For the rigorous pattern theory created by the author-mathematician, chemistry is just one of many applications or embodiments of pattern transformations, and history, as far as it can be presented as points and lines, is yet another one. In the reception room of pattern theory, history and chemistry humbly sit side by side with other applicants.

We have just explained our interest in the alternatives. What about altercations? The reason why the witnesses of the demise of Robespierre did not remember the weather of that day could be just because of the general excitement of the moment. It is well known that people in the state of agitation and anxiety can have contradicting views of the fast moving events. Many hundreds of people witnessed the assassination of President Kennedy and still there was a wide range of testimonies. Revolution and war involves high emotional *temperature*, and temperature is the measure of *chaos* and inherent deviations from the statistical mean. If a chemical reaction is conducted at a high temperature, it runs fast, but usually gives a larger variety of undesirable products. We will come back to this subject later.

But first we should look around for our contenders and allies in the quest for a universal message. We would like to find a place for our ideas among other intellectual currents of the modern era, as we have already found it among doctrines of antiquity.

5. Three views of the world

There is an immense literature on most general aspects of history. It starts with mythology that explains the present state of the world by unique events of the past, which can never be repeated. Philosophy of history is also a rich and interesting subject, but here we are much more interested in the way natural scientists approach history: the phenomenon that they do not professionally study but just partake as citizens. This would allow us to find our own place on the conceptual map.

We would like to select two modern general views of the world. They belong to scientists working in particular areas, far from history, as well as from each other. We would roughly characterize them as substance philosophy and process philosophy. One has been summarized by Edward O. Wilson (1998) in his recent *Concilience: the Unity of Knowledge*, the other was developed and summarized by Ilya Prigogine in a series of books, among them *Chaos out of*

Order written with Isabelle Stengers (Prigogine, 1984). We must emphasize, however, that the two views are neither contradictory nor antagonistic: they are allies against non-scientific views of the world that we do not consider here, with the exception of mythology and ancient medicine. We must say from the start that we have no bones to pick with either view.

We start with the first author.

> The legacy of Enlightenment is the belief that entirely on our own we can know, and in knowing, understand, and in understanding, choose wisely. That self-confidence has risen with the exponential growth of scientific knowledge, which is being woven into an increasingly full exploratory web of cause and effect (Wilson, 1998).

In practical terms, the central idea is: starting from the physical picture of the world, we can trace its fundamental laws and regularities to the upper floors of complexity where society and individuals dwell. We can understand what people most need, and how they go about getting it, from their biological and social nature defined to a great extent by genetics.

The world according to this picture looks comprehensible, capable of stability and balance, and not quite responsive to the whim of individual desire and will. There is a global criterion for wise and unwise actions, one for all. This is the classical picture of the world, going back to the French Encyclopedists, Newton, and further back to Galileo. We would compare this world with a palace or labyrinth which, however large and intricate, can be explored and mapped.

> The central idea of consilience world view is that all tangible phenomena, from the birth of stars to the workings of social institutions, are based on material processes that are ultimately reducible, however long and tortuous the sequences, to the laws of physics (Wilson. 1998).
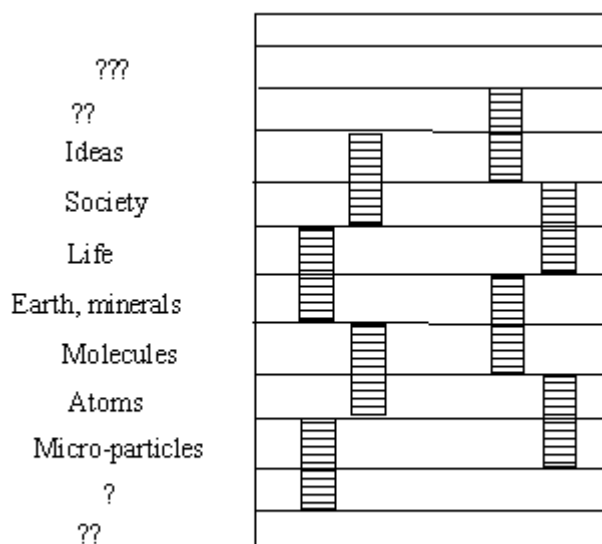
Figure 5.1. The tower of reductionism

We attempt to illustrate this view, often called reductionism, with Figure 5.1. We compare all knowledge with a tall building. Every floor of the world, usually inhabited by a particular science, can be understood in conjunction with both upper and lower floors. Thus, life was formed due to specific conditions on planet Earth. Its evolution points in the direction of human society, greatly influenced not by winds and earthquakes but by ideas generated in human heads. Earth itself is built of molecules, i.e., combinations of atoms. The peculiar behavior of molecules can be explained only if we take to account their fine structure, and so on: the building is never finished, it is in perpetual remodeling and refurbishing, and we do not even know how big it is and whether it has the foundation and the loft.

The floors communicate through staircases that connect each floor only with one floor up and one floor down. For example, from the molecular level we can go up to minerals or down to

atoms along the same stairs. If we are pros in molecules and get interested in life, we have to change the staircases because there is no direct connection between molecules and life unless we take to account the properties of the earth surface. Life is a peculiar kind of a mineral, a non-periodic crystal, as Erwing Schroedinger (1996) prophetically noted in the 1940's.

The concept of reductionism itself has been evolving for centuries and there could be multiple perceptions of what it means. As another illustration, we shall compare two discourses that exemplify the latest concept of reductionism pertaining history.

First discourse. Jared Diamond (1997) in his book *Guns, Germs, and Steel*, asks the descending ladder of questions that explain *why* in November 1532, at Cajamarca, Francisco Pizarro with 168 soldiers captured the Peruvian monarch Atahuallpa with his 80,000 strong army. The answer to this first *why* is the obvious military advantage of Pizarro with his steel, armor, horses, and guns. But *how* did Atahuallpa come to be at Cajamarca? Jared Diamond points to some preceding events, including civil war among the Incas, as well as an epidemic of smallpox. The next *why* is how Pizarro came to Cajamarca? The answer is that he had command of the Spanish maritime technology combined with state organization, while the Incas had no such means. Next, "*Why* did Atahuallpa walk into the trap?" Because he did not have correct information about the Spaniards, their power, and intent. On the contrary, Pizarro, although illiterate, possessed a large body of knowledge (Diamond, 1997).

Jared Diamond further traces the chain of causation deeper and deeper back into the past, for about ten thousand years, until there is no answer.

Second discourse. Steven Weinberg (1992) in his book *Dreams of a Final Theory* descends another staircase of why's, starting with: *why* is chalk white? Because light interacts with chalk. *Why?* Because light has certain wavelength and its interaction with matter is selective.

Why? Because photons, the particles of light, interact with atoms, which can be in discrete states. *Why?* Because of the wave properties of electrons "vibrating" at certain frequencies. Why are there particles like electrons? Because elementary particles are combinations of quarks, etc, until there is no answer.

The first discourse is a continuation of the second one, although in a very different logical key. Diamond, a historian, looks at the temporal sequence of events. Weinberg, a physicist, looks at the timeless properties of matter. The problem is that there is a gap, about one hundred million year wide, between the chalk, which consists of remains of simple microscopic organisms, and the emergence of human beings with their tools, gardens, and livestock. Even wider gap exists between the physical and historical approaches, and Steven Weinberg is well aware of it, not to mention the abyss between creationism and evolution.

Steven Weinberg, a passionate defender of reductionism, notes:

At the other end of the spectrum are the opponents of reductionism who are appalled by what they feel to be the bleakness of modern science. To whatever extent they and their world can be reduced to a matter of particles or fields and their interactions, they feel diminished by that knowledge.... The reductionist worldview is chilling and impersonal. It has to be accepted as it is, not because we like it, but because that is the way the world works (S. Weinberg, 1992, p. 52).

Brian Greene, author of one of the recent books on "theories of everything" , comments:

Understanding the behavior of an electron or a quark is one thing; using this knowledge to understand the behavior of a tornado is quite another. On this point, most agree. But opinions diverge on whether the diverse and often unexpected phenomena that can occur in systems more

complex than individual particles truly represent new physical principles at work, or whether the principles involved are derivative (B. Greene, 1999).

While a small system just goes straight through its limited number of states, passing them many times, like a car cruising the streets of a small town, only a very large system is capable of a unidirectional irreversible evolution when only a small part of the system changes at a time and the possibilities of change are uncountable. Whether we call it evolution or history, it seems to be an inherent property of all large and complex system, including galaxies and the Earth's crust

This is where the second world view steps in.

The second view of the world deals with the property of complexity. It is less interested in how the world is built than in why it is as we know it. It comes from Ilya Prigogine, a scientist who contributed much to expanding foundations of physics beneath systems similar to life and society, i.e., evolving systems with the past, present, and future. His more serious and technical book is *Exploring Complexity* (Nicolis, 1989).

Scores of popular books have been written about this subject. In short, some phenomena, like society, life, and weather, belong to so-called dissipative systems. They are in perpetual change and never reach equilibrium because they consume energy, filter order out of it, and dissipate chaos as heat. In this way they maintain a high degree of order. The dissipative nature of life can be seen in any dog or cat: it eats food made of animals and plants, dissipates heat, and ejects food of a lower nutritional value for insects, microbes, and plants. The sun runs the show by growing plants.

The dissipative nature of a simulacrum of life can be seen also in a robotic toy dog: it should be plugged into an electric socket from time to time (or supplied with batteries) and it dissipates heat.

The behavior of some complex dissipative systems does not allow for long term predictions because of the inherent instability of such systems. They are subject to large catastrophic changes resulting from small causes. Charged with energy, such systems are capable of dramatic amplification of small fluctuations. Not only the future is unpredictable in principle, but the past, too, may not have a rational causal explanation. This view points back to Heraclitus, who said "We step and step not into the same rivers; we are and are not," usually translated as "we cannot step into the same river twice".

Ilya Prigogine made a decisive contribution to the area of non-equilibrium thermodynamics, for which he was awarded Nobel Prize in 1977. Unfortunately, we cannot dwell here on Prigogin's arguments, and can only refer the reader to his remarkably rich books. We can only slice off a thinnest layer of his ideas, but with a thick sauce of interpretation.

Nature, following our analogy with building, according to Prigogine, is not the building but the process of its construction. It is much less organized, however, than what builders do on the construction lot. The unfolding of history is similar to repetitive rolling and folding a piece of dough.

Anyone can conduct the following experiment: we put two raisins together at one spot, knead the dough, and they go apart and move in the dough in an unpredictable manner. Both authors of this book, one, an ardent home baker, and the other, a new convert, can confirm this observation.

Ilya Prigogine uses this so-called baker's transformation to illustrate the inherent instability of social systems and the particular kind of time in them.

NOTE: The once popular concept of "punctuated equilibrium" (Eldredge, 1972) falls into the same general framework of alternating stability and instability.

The baker's transformation is shown in Figure 5.2. We start with a piece of dough with two raisins, dark and light, side by side, and flatten this piece down to half its initial height (**A** and **B)** and twice its length. Next we fold the dough (**C**) and roll it again (**D**). This operation of mixing will unavoidably separate the raisins, more and more with each new stage. Finally, when the other raisin reaches the opposite side of the dough, we arrive at an uncertainty: a slight change in the position of the raisin and conditions of folding and rolling will result either in **K** or **L**.
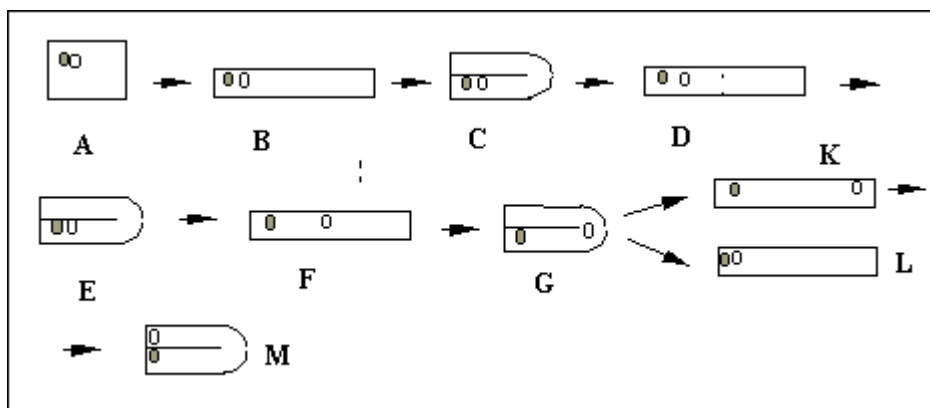
Figure 5.2. Baker's transformation

The baker's transformation is not what is called "butterfly effect," when a butterfly flapping its wings in Beijing may cause a storm next month in New York, but they both belong to the type of behavior with inherent instability. A tiny difference in initial conditions leads to a big and in principle unpredictable difference in potential results.

Neither Prigogine nor Wilson discuss problems of history in any detail, and their juxtaposition, as well as the following reasoning, is entirely authors' responsibility.

History seems to confirm the butterfly effect. An apple, according to a myth, caused the Trojan War in the twelfth century BC, and the murder of Archduke Francis Ferdinand in Bosnia

on June 28, 1914 ultimately caused two world wars in a row. One might say that if not that accident then something else would trigger the war and set free the accumulated energy of both weaponry and nationalist passion, but this assumption would be beyond any test.

The example with the raisins means that a transformation of a system can be so drastic that it does not preserve topology, i.e. the general shape of things.

Applied to historical configurations, it means that two close points have high chances to be separated during the evolution of the system. The latest example are Germany, Vietnam, Korea, and China divided by the Cold War between Capitalism and Communism. The two still separated Koreas, in spite of the large body of common language, culture, and history, are, in a sense, two raisins touching each other but divided by an impenetrable wall of political topology, as if we folded **K** into **M.**

A similar wall was forcibly removed by the North Vietnam and spontaneously by the two Germanies in the twentieth century. Another wall was erected and fell as result of the American Civil War. A big blob of dough fell apart in former Soviet Union.

The great movements of people throughout history also remind dough kneading, which we can trace by language. Thus, people speaking Finno-Ugric languages are encountered in disconnected areas spanning from Hungary to Baltic Sea to Eastern Siberia. Altaic languages cover even a longer stretch of Asia between its Mediterranean and Pacific coasts, scattered along the routs of westward moving Huns and Mongols. As far as the Basque language is concerned, we do not even know whether the other raisin has ever existed and where to look for its seeds.

In the course of historical kneading, most kings and queens got separated from power, and some of them even lost their heads. Monarchy, the common way of governing society in the

seventeenth century, became a symbolic link with the historical past and part of cultural heritage, even more secure and respected than in times of absolutism.

The view of the modern version of reductionism seems to find support, too. We can trace the roots of the inherent internal stress in the Southern Slavic region of the former Yugoslavia back to the great contest between the descendants of the Roman province Illyricum and the advancing Ottoman Empire. Subsequently, this area was kneaded, stretched, folded, rolled, and torn apart by many hands, as well as by internal fermentation. It was initially formed and kept together by the authoritarian force of Serbian king Alexander I (assassinated in 1934) and Croatian Communist Josip Broz Tito (died in 1980) while both leaders were alive.

Following the concept of consilience we may hope to explain the violent nationalism by the genes and modes of behavior inherited by humans from their animal predecessors. In our explanation we would have to turn to social psychology and its studies of liking, frustration, and displaced aggression.

We should take to account the unique peculiarity of the Yugoslavian territory populated with people of four different religions and three alphabets, and with historically alternating record of domination of one nation over the others. The fact that all of them, except for ethnic Albanians, speak identical or very similar languages and have a strong feeling of belonging to the same family of Southern Slavs, is a certain prerequisite for the family being dysfunctional.

From this point of view we would probably conclude that the recent situation was by no means accidental and could not be any different. When Father West had taken up the paternal authoritarian role played previously by Alexander I and Tito, his Serbian stepson displaced his aggression onto his brothers and sisters. We suspect, however, that this kind of research could resurrect the pattern of Giordano Bruno and zealous political correctness.

This approach would fail if we considered the dissolution of the Soviet Union. The people of former Russian Empire mostly neither spoke the same language nor were pressed to, and neither knew any other dominant nation except Russians nor had any big internal ethnic conflict on their historical memory, with the exception of some small Caucasian nations like Chechens and Circassians in the nineteenth century.

The major difference between diagrams in Figures 5.1 and 5.2 is that one is static and the other indicates its dynamism by the arrows of transformations. One sees the world as a layered cake, the other sees it as making the cake.

The dynamic, "processual" (Prigogine) and static, "substantial" (Wilson) points of view are evidently complementary. Some philosophers and scientists mean by reductionism any impersonal, scientific explanation. We must acknowledge our debt to reductionism which has created the largest and the most widely used in practice body of knowledge. Reductionism, especially, as refined a concept as consilience, "interlocking of causal explanation across disciplines" (Wilson, 1998), is the very spirit and flesh of modern science.

As far as history is concerned, its sharp revolutionary turns and periods of discontinuity are similar to baker's transformation: colonization and decolonization, revolution and restoration, separation and reunification, dictatorial coup and democratization, imperial rise and fall, fast technological change: roll and fold, roll and fold… As result, we can see both the remarkable continuity and diversity in patterns of culture around the world.

We all knead the same dough but bake our daily bread in different shapes every morning.

Both points of view are difficult to dispute, but none has ever been tested on particular historical events. Most of very general statements are true even if they exclude each other.

According to one of the founders of modern physics Niels Bohr, this is exactly the criterion of a great truth: the opposite of a great truth is also a great truth.

There is one thing, however, that points to a substantial void in the complementary union of two points of view. The world remembers its past. The past as distant as that of the Bible, not to mention the past as young as several hundred years, is still capable to shape history of a region. The initial conditions are lost in baker's transformation or in another mathematical model known as Markov chain (the next moment events depend only on the cast die and the events the previous moment, but no further back), but they are not lost in historical records and national memory.

Prigogine concentrates on the problem of time and change, while the resilience of memory seems to be left on the wayside. The reason for that is the choice of a physical model by Prigogine: it is a dynamic system with gas and liquid as its closest embodiments. In other words, it is a system full of motion and it should be analyzed at two levels: microscopic and macroscopic and only the last one is observable.

Turbulence is one of Prigogine's favorite illustrations of dissipative structures: when the energy of liquid flow reaches a certain level, from a smooth uniform laminar flow with no visible peculiarities it turns into a turbulent flow with eddies visible with the naked eye. Each eddy is a coordinated and organized movement of large numbers of individual molecules of water. It looks chaotic, but it is full of order because the eddies have a certain average shape and size. To support the order in a dissipative structure we need to spend additional energy: to pump a turbulent fluid is more difficult than a laminar one.

According to R.G.Collingwood (1954), the historian's task is to show how the present has come into existence. There is a difficulty of the transposition of the concepts derived from

the behavior of continuous fluid bodies to the social structures that behave more like solid bodies of a particular and intricate design (compare with the Crane Brinton's image of history as network), which from time to time lose and acquire some parts and rearrange others. Collingwood himself saw in history the transformation of ideas, to which neither physical continuity nor classical thermodynamics could be applied.

The central concept of Prigogine's thermodynamics—the emergent behavior—was further explored by the team of the Santa Fe Institute of Complexity on non-physical discrete models. It was summarized by Stuart A. Kauffman in *The Origins of Order* (Kauffman, 1993) and, in a more accessible form, *At Home in the Universe* (Kauffman,1994). Order comes from chaos when certain parameters reach critical levels, which is exactly the essence of turbulence.

The works of Stuart Kauffman and other authors united around Santa Fe Institute of Complexity is a very big topic with history of its own and we can only refer the reader to the sources. The major contributors are mentioned in: Kauffman (1993, 1994). *Artificial Life* by Christoph Adami (1988) should be added to the list. Manfred Eigen (1972, 1993) was the pioneer in this area. He contributed the powerful idea of selection of *configurations known in details*, i.e., structures, to the more diffuse thermodynamic picture.
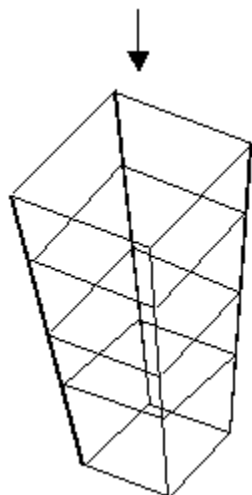
Figure 5.4. The pattern view of the world.

We come now to the third, pattern view of the world. It is metaphorically presented in Figure 5.4. It is a bird's eye view through the entire building of Figure 5.1 as if the bird had an X-ray vision. We would not see much: just the shadows of the rich, colorful objects, but we would discover the same shadows at almost every floor. We could see the unity of the world.

For a chemist, water is not just zillions of molecules dashing in a table spoon of clear liquid but an immutable structure built of two atoms of hydrogen connected at an angle to a single atom of oxygen. This is what water has always been since it first formed in the universe and this is what it will be forever while the universe lasts. In the peculiar and unique view of the chemist, water is not the drinkable liquid but its individual molecular pattern made of two atoms of hydrogen and one of oxygen. Paradoxically, the chemist perceives the molecule of fluid water as a flexible but solid body. Plato and Spinoza would say that the chemist deals with the idea of water.

The body of a molecule, although subject to internal movement such as vibrations and deformations, cannot be described in terms of collisions, ensembles, dynamics, and mass

statistics. It can be done only in terms of structure. Society, too, reminds a solid body, a crystal, with most atoms moving only within a certain limited space. The portal of an Internet search engine shows the modern dimensions of human life : work-home-shopping-travel-sports-money and little else more. The solid body is deformable, however.

The structure of an individual molecule changes in the course of chemical reaction once and forever as a unique catastrophic event, overshadowed by the statistics of a macroscopic amount of matter. The V-shaped molecule of water can be stretched and bent, but it remains water, unless broken. It breaks like a solid body and can be resurrected from the same pieces, if we manage to catch them while they scatter around like frightened mice.

NOTE: We omit here an important but technical subject of reversibility

The closest parallel with molecule is a three-dimensional geometrical figure, such as, for example, Platonic bodies: tetrahedron, cube, etc., only it is not typically symmetric. We can compare it also with a modern sculpture made of rods and balls. A mobile sculpture, like that in Logan airport in Boston, has a lot of internal motion, but remains itself.

How can anything as static as a solid body have any relation to history?

If molecules were just static, there would be no chemistry. They change but not the way dynamic system studied by physics do. They change atom by atom, connection by connection, and we can imitate this structural change by small balls of modeling clay and cocktail straws, or simply, as chemists still do, with pen and paper. Structural chemistry is a science of the individual object, not the crowd. Yet making cake is also within the chemist's expertise, and it means fermentation, the subject we will touch upon later.

The third, structural, approach does not contradict the other two. It grew, however, from different roots, planted by Democritus, and perceives the world in terms of atom-like blocks

arranged in a certain order. In short, it is about structure, usually shunned by physics and taken as granted by reductionism. History, from this point of view, is always a concrete arrangement of such blocks as particular, not abstract, event, person, idea, territory, power, relation, etc., which changes according to certain rules and laws, whether smoothly or catastrophically. The change is never fully predictable and only partially explainable. Believe it or not, the same holds for chemistry, but the computers are really a big help.

The third view notes a certain similarity between ancient kings, modern dictators, and even the charismatic CEOs. It understands the phenomenon as pattern, i.e., a property of human society that is neither accidental, nor completely reducible to any lower level, but akin to the way water vapor crystallizes into different snow flakes, all having the symmetry of the six-ray star.

We are not going to reduce history to chemistry, however. As we promised, we will introduce elements of a much more general and abstract mathematical approach, for which chemistry itself is just an illustration.

Until now we have not dealt with any mathematics. Next we are going to explore mathematical objects somewhat similar to molecules but more abstract. The constructs made of points and lines are subject of the area of mathematics called graph theory, and we need to take at least a superficial tour over its terrain before entering the realm of patterns.

6. Graphs

The drawings consisting of points and lines represent mathematical objects called graphs, Figure 6.1.

Graph is a set of "points" called nodes and "lines" called arcs. Today the terms **points** and **lines** are also acceptable. The drawing is the pictorial representation of a graph, but it is not the only one: square matrix or table work just as well. Thus, graph **A** can be represented by a 4 x 4 matrix, Figure 6.2A. Each point enters twice: in a column and a row. In each intersection of a column and a row the unity means a certain relationship (line) between two points, and zero means its absence. We can read this matrix as follows: there are two points, point 1 (see first row) is connected with points 2 and 4 (second and fourth columns), point 2 is connected with points 1 and 3, etc.
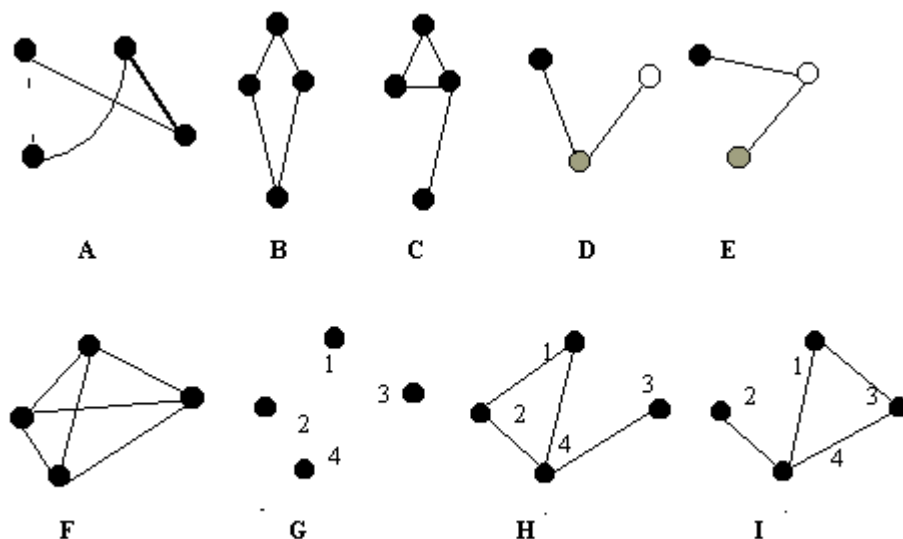
Figure 6.1. A variety of graphs: points and lines.

The matrix only looks like a square, but in fact we can cut it out and roll into a cylinder along the rows or columns. We can now cut this cylinder along a generatrix between any two rows (Figure 6.2) and any matrix will represent the same graph. Thus, graphs **C** and **D**, Figure 6.1, and **A** and **B**, Figure 6.2, are the same.

Graph is neither plot, nor chart, nor diagram. It is a mathematical object reflecting an essential aspect of what is commonly understood as structure. The arcs may mean lines drawn by a pencil, or telephone lines, or friendships, or anything else, totally invisible, as long as there are a set of nodes and a binary relationship between all or some or none of them.

Arc, therefore, is a representation of a relationship, and whether we portray the arc with thin, thick, long, short, straight, or curved line, it does not matter because all of them simply mean that two nodes are linked in a relationship.
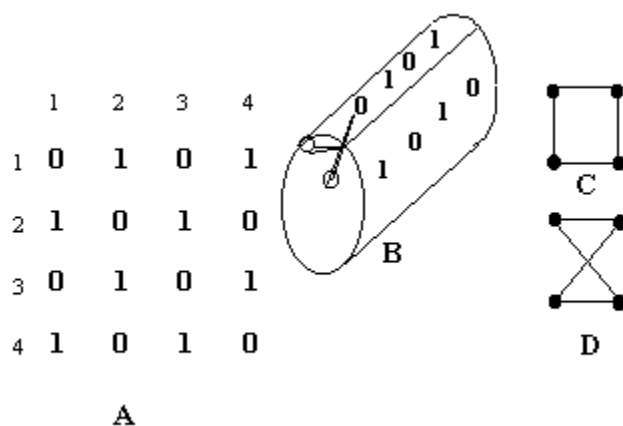
Figure 6.2. Graph as matrix of incidence

In simple graphs all nodes are equal and so are all arcs. The graph remains the same if we switch any two nodes or arcs. Therefore, in Figure 6.1, simple graphs **A** and **B** are identical, while **B** and **C** are not, and matrices for them are different. Graph **G** has no nodes at all but it is still formally a graph. In graph F all nodes are connected, making it *full graph*. Thus, the structure of the interstate commerce in the United States is a full graph on 50 nodes, all states having potentially same ties with each other, indiscriminately. Not accidentally, the first thirteen stars on the American Flag were arranged in a circle.

The simplicity of the simple graphs follows from the liberal use of the words "equal" and "does not matter" in their description: size does not matter, distance does not matter, etc. We can invent a variety of more complex graphs by allowing more diversity but less equality.

We can distinguish between nodes by labeling each of them with a number or a specific color, so that graphs D and E , as well as H and I , Figure 6.1, are different. Such graphs are called colored. Similarly, the arcs can be labeled too. They can also be drawn as one way street,

with a direction from one node to another. For example, in a graph of subordination within an organization, which normally looks like an upside down tree, the link goes from the superior to the inferior.

Our illustrations will consist mostly of points and lines, but we will not deal with simple graphs. The real world does not know either zero diversity or absolute equality. We may portray points by dots of different size and shape and fill them not only with black paint but with their names in Latin letters, and distinguish between different kinds of arcs by drawing them with different types of lines.

It is appropriate here to compare graphs and geometrical figures, for example graph and triangle in Figure 6.3.
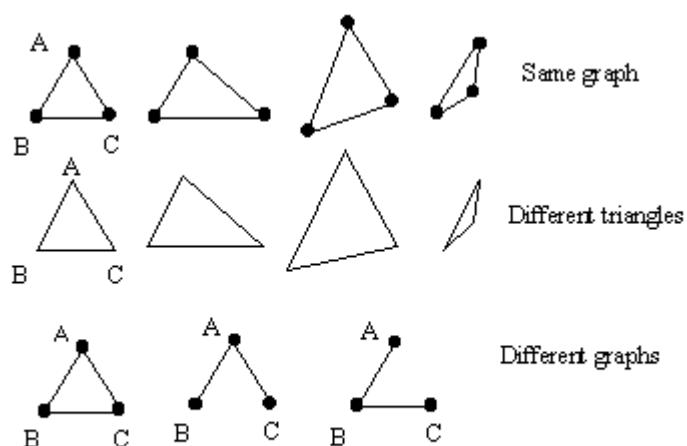

Figure 6.3. Graphs and triangles

The relation of being neighbors, or, more generally, being in a relation, is the essential subject of the mathematical discipline called *topology*. This term has two meanings: the name of the discipline and a property of a set of objects. Topology as science takes a set of objects, for example, points on a surface, and for every pair decides whether they are neighbors or not.

Among other problems, the science of topology studies which points remain close when the surface is deformed, i.e., whether topology as property is preserved. Thus, when we have an orange made of modeling clay and make a cucumber out of it, topology is preserved, but if we make a donut, formerly close neighbors become separated. Taking another example, basketball and American football have different shape but the same topology, while bagel and muffin are worlds apart, although they are both as American as apple pie.

We can stretch and twist the rubber band, but this does not change its topology: any two infinitely close points will remain close. If we cut it, the relation of closeness between some points will be lost, unless we glue them back. In political terms, topology is preserved in a transformation without revolutionary scissors and authoritarian glue.

Graph is an example of a topological set because it is a binary relation between every two nodes that are either connected or not at all. The arc in a graph symbolizes exactly the relationship of neighborhood or vicinity: each node is the neighbor of all other nodes connected to it with their arcs.

Triangle also has a topology, and it is preserved when we deform it. However, Euclidean geometry, unlike topology, takes to account angles and distances, and if those are changed, the new triangle is different from the old one. What is of interest for us here is the common property of all triangles, their pattern of "triangularity" or "triangleness," preserved under all transformations.

Figure 6.4 shows what we can do with a triangle without violating it "triangleness." We can move it in its plane (A), rotate it, and stretch it uniformly (C) or unevenly (D). All this does not change the property of being triangle.
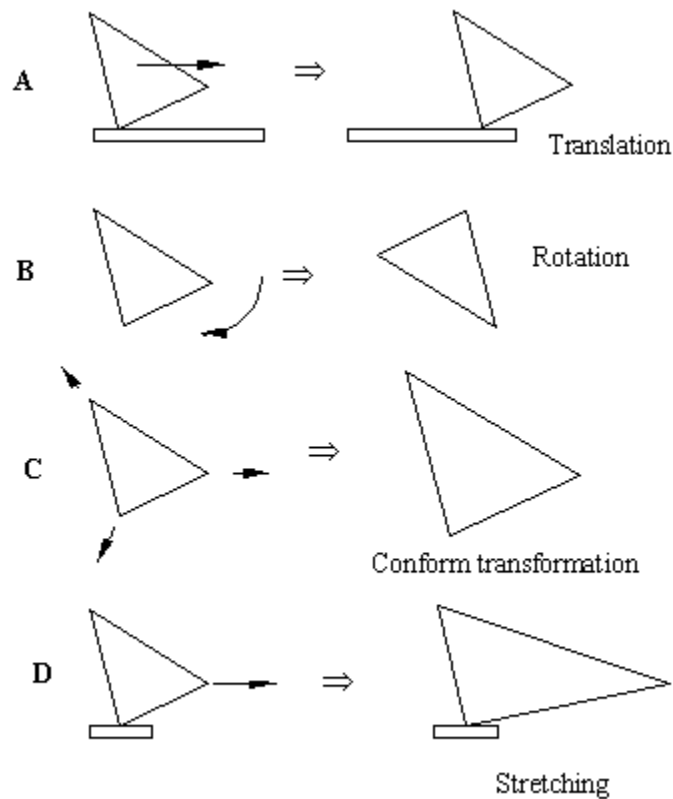
Figure 6.4. Geometrical transformations of triangles

A rhetoric question: what can we do with democracy without breaking its topology?

Some triangles and other figures possess the mystical property of symmetry. Symmetrical figures can be subjected to a series of operations that turn them into themselves, see Figure 6.5.

For example, we can rotate the triangle in the upper row around its vertical axis until it falls back into the plane. This new triangle is not the same because we have changed vertices B and C. When we repeat the same operation again, we come back to the initial triangle.

We can also rotate the triangle around its center for 1/3 of the full cycle. If we label the vertices, we have to do that three times in order to come back to the beginning.
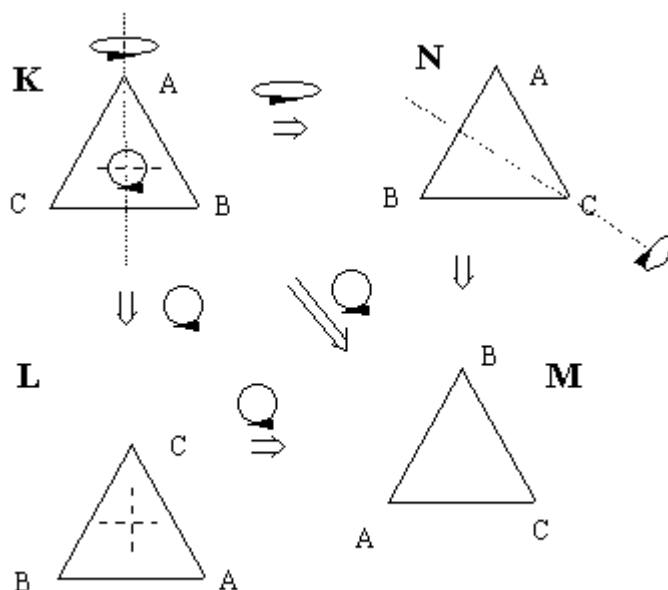
Figure 6.5. Symmetry operations with triangles

The transformations of triangles invite us into a different hall of mathematics called group theory, and we will enter it in Chapter 8 plainly called *Groups*.

After our short encounter with graphs we can clearly recognize Figures 2.1 and 2.2 as graphs and thus start building a mathematical bridge between history and points and lines. By the way, the bridge in the Prologue (Figure P.1) is a graph, too.

7. The King and the Pear

It may seem that an impenetrable divide exists between geometry of triangles and the fabric of social and personal change. Is the common expression "love triangle" anything but metaphor?

We would like to provide more illustrations of the evasive property that falls within such overlapping terms as invariance, regularity, order, and structure. In general, this property is something that is preserved under spatial, temporal, or *other* transformations. The class of *other* transformations is what interests us most.

Not everyone is aware of mathematics' ability to deal with objects that seem to inhabit the mysterious realm existing without space and time. Thus, the "triangularity" described in the previous chapter had nothing to do with either the ruler or the clock. An operation can be applied to totally disconnected objects. However strange it sounds, operations can be applied not only to connected points, as in the previous chapter, but also to disconnected objects.

Following is an example of invariance bringing together two objects as dissimilar as the King and the pear, and is borrowed not from Lewis Carroll but from a book on history.

Figure 7.1 is a contemporary caricature of Louis Philippe, king of France (1830-1848), deposed by the Revolution of 1848. The transformation of the head into the pear preserves the pear-like shape.

Figure 7.1 *King Pear. A contemporary caricature of Louis Philippe (from Webster, 1925)*

The second example (Figure 7.2) is borrowed from a serious book on mathematics (Yaglom, 1988). The picture illustrates one-to-one correspondence which allows for establishing similarity between different sets.

This figure shows two extreme types of transformation. Transformation in (a) changes one discrete set of figures into another one, so that there is one-to-one correspondence between the two sets. One example of this transformation is a remake of a classical play where characters of a Greek or Shakespearean drama are transferred into contemporary surroundings. As another example, we would mention didactic folktales and fables whose creators—from Aesop (620-560 BC) in Greece to anonymous Sanskrit authors of *Panchatantra* (approximately 300 BC to 400 AD) to La Fontaine (1621-1695) of France—transposed typical human collisions into situations

among animals. Every epoch, up to our times, made the reverse transpositions of the immortal patterns.

The figures of set α have a difficult-to-define similarity to their counterparts in set α_1 when only considered through visual associations between the pawn and the slouching man, the bishop and the woman in a skirt, the rook and the square outline of a jacketed man, and the king and symmetric wide sleeves of a woman in a robe.
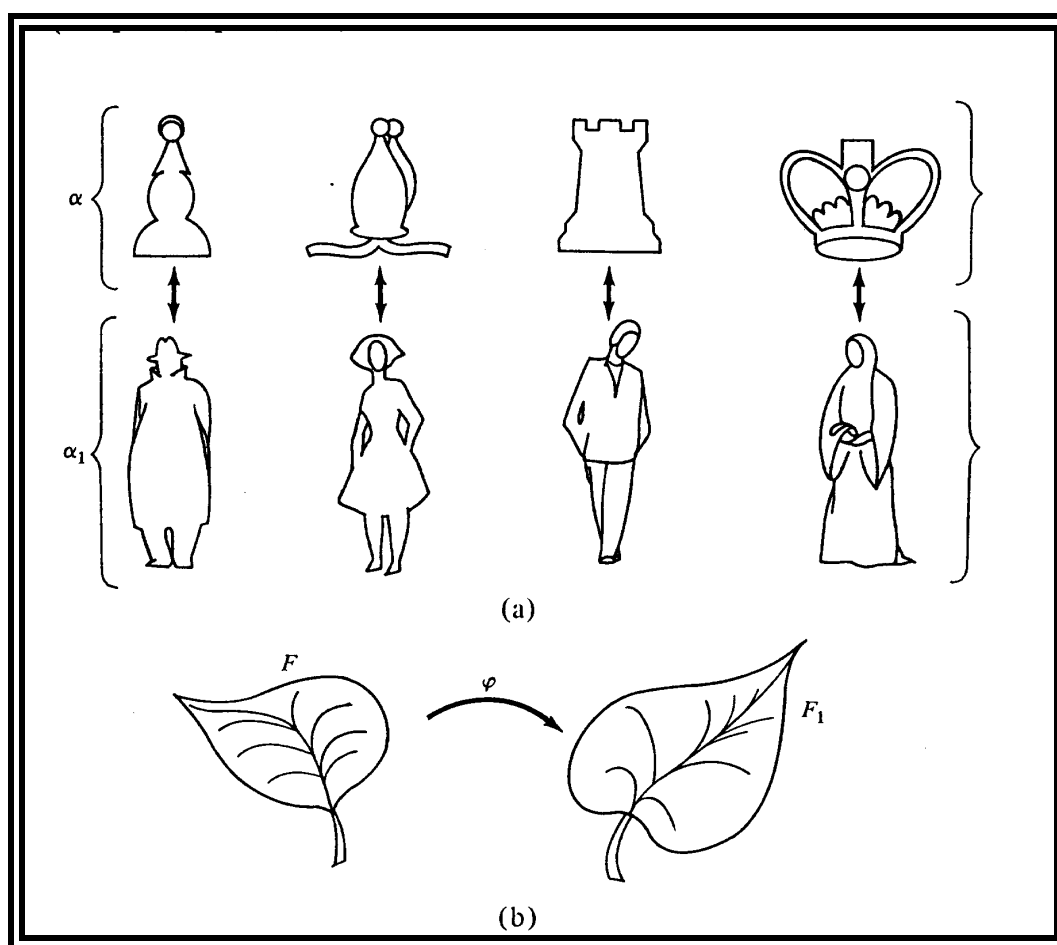

Figure 7.2. One-to-one correspondence (a, a_1) and isomorphic deformation (b). From *Yaglom (1988)*

Transformation in (b) is continuous: it changes the distances and angles yet preserves the general shape in the same manner transformation in (a) preserves functional roles. To be more precise, it preserves the topology of the figure: two close points in item F are as close in item F_1. A small violation of this rule is noticeable as an extra vein on the left side, and we do not know whether it was intentional or just the manifestation of a universal chaos.

Thus we can regard stagnation, equilibrium, evolution, and revolution as something that does not change during transformation from one society to another. This concept of regularity as invariance of transformation constitutes the core of the mathematical apparatus of pattern theory and establishes a close relation between pattern theory and geometry. Geometry is not merely lines, just as mathematics is not only numbers. In this sense, pattern theory is a geometry of everything.

Here is a totally different example of invariance, however, which is also taken from a book on mathematics.

> "Daddy, I know a good joke: 'Why do white sheep eat more than black sheep?'"
>
> "I've no idea".
>
> "Because there are fewer black sheep than white sheep!"
>
> If Daddy had wished to "repeat" this joke in his club, he would probably have altered it: "Any of you chaps know why Americans drink more whisky than Scotsmen…?" Here we have an example of what we might call *isomorphic jokes*; they are really the *same* joke, but placed into a different context (Budden, 1972, p. 131).

Using points and lines, we can portray the structure of the joke (see Figure 7.3). The joke is based on the ambiguity of language where a word **B** may mean either A_1 or A_2. The

expression "animals **X** eat more than animals **Y**" (**B**) is ambiguous and it can mean that "each animal **X** eats more than each animal Y" (**A₁**) or "all animals **X** together eat more than all animals **Y**" (**A₂**). The two meanings are tied together by the common "**X** eat more than **Y**" in the same way the rain and the rain invocation ceremony (see Chapter 1, *Post Hoc Ergo Propter Hoc)* are linked by the sprinkling of water.
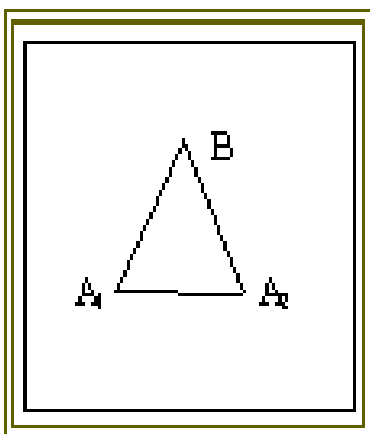
Here is another version of this type of joke from the *Prairie Home Companion Joke Show*, 1999 (National Public Radio):

Figure 7.3. *The joke triangle*

Why there are so many Smiths (**B**) in the phone books (**A₁**)?

Because they all have phones! (**A₂**). The logic of the joke, therefore, identifies that **B** is **A₁** because **B** is **A₂.**

The question involves names (**A₁**), the answer is about phones (**A₂**). The common subject results in the large number (**B**). The missing serious answer should involve names.

The pun jokes have the same triangular pattern, but no serious answer, for example:

Why did a scientist put a knocker on his door?

Because he wanted a Nobel (No Bell) prize

(*National Public Radio*)

Or a more sophisticated pun:

> René Descartes enters a bar and the barman asks "what would you like to drink?"
>
> "I don't think I want to drink" says Descartes and vanishes. (NPR)

A historically important triangle is the perception of the same act **(B)** by two different sides **(A_1)** and **(A_2).** John G. Stoessinger in his "*Why Nations Go to War*?" regarded mutual misperception of sides as well as of themselves as the primary precipitating factor of war, and it may be true about any conflict (Stoessinger, 1974).

For example, a bombing **(B)** of the Chinese embassy in Belgrade during the Kosovo conflict in 1999 was perceived as an accident **(A_1)** by NATO and a barbaric act **(A_2)** by China. The similarity of the situation with that of a pun is that both **A_1** and **A_2** are logically compatible, i.e., an order to commit a barbaric act could be made by accident. Yet in international relations this pattern is a typical source of conflict and by no means a joke.

The Chinese-Western triangle of misperception has tangled roots.

In 1793, King George III of Britain sent Lord Macartney to China with the purpose of establishing a diplomatic representation at the Imperial Court at Peking and enhancing trade, in accordance with the accepted practice in Europe and its surroundings .

Emperor Ch'ien Lung, sometimes compared regarding his grand style with that of Louis XIV of France, denied the request. He did not see anything of interest for China in this trade and he wrote a lengthy letter to King George .

The following excerpt illustrates:

Your proposed Envoy to my court could not be placed in a position similar to that of European officials in Peking who are forbidden to leave China, nor could he, on the other hand, be allowed liberty of movement and the privilege of corresponding with his own country; so that you would gain nothing by this residence in our midst.

Europe consists of many other nations besides your own: if each and all demanded to be represented at our Court, how could we possibly consent?

Moreover, our dynasty, swaying the myriad races of the globe, extends the same benevolence toward all.

But your Ambassador has now put forward new requests which completely failed to recognize the Throne's principle to 'treat strangers from afar with indulgence' and to exercise a pacifying control over barbarian tribes, the world over.

Nevertheless, I do not forget the lonely remoteness of your island, cut off the world by intervening wastes of sea, nor do I overlook your excusable ignorance of the usages of Our Celestial Empire. I have consequently commanded my Ministers to enlighten your Ambassador on the subject, and have ordered the departure of the mission.

(*Schurmann, 1967, p. 105*)

Conceivably, the reader might say that perception and culture may be different, but common sense and reason that allows people to understand one another should not. Wasn't the imperial answer a refined joke?

The reader could look for an answer not in history, but rather, along the reductionist principles (see Chapter 5, *Three Views of the World*) in psychology. Emperor Ch'ien Lung of the Ch'ing dynasty ruled China for sixty years, (1735-1796), and by the end of his rule showed signs of impaired judgment. But the subsequent story of China-West relations tends to confirm
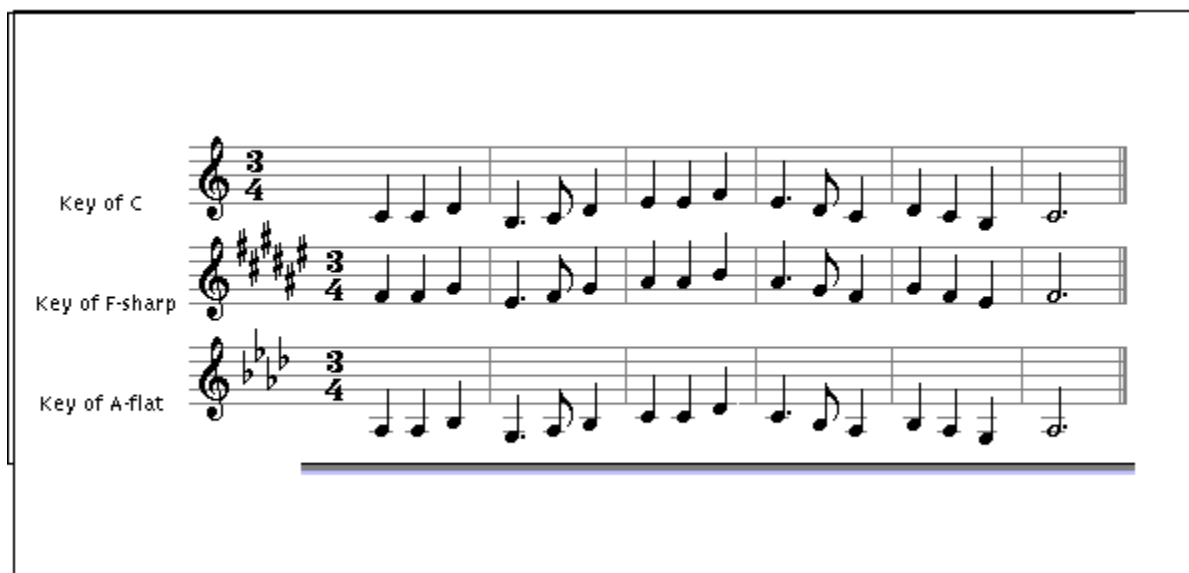
that it was the fundamental difference of cosmic dimensions in political patterns that made a rapprochement painful for both sides.

The old Chinese pattern could be called Cinocentric, similar to the geocentric pattern of Ptolemy, with the Emperor ruling the Earth under the mandate of Heaven and all the peripheral Barbarians as his tribute-paying satellites.

In the span of fifty years, the self-image of China and her image of the world was to be crushed in the Opium War (1839-1842), but a century later the West entered a long process of re-educating itself about China, sending new missions, losing wars, and learning the language of humility and apology.

We shall return to some internal patterns of China in Chapter 25, "The Circuitry of Imperial China".

Among *other* transformations with underlying mathematics, is, for example, the transposition of a melody from one tonality (key) to another, (*see Figure 7.4*).

Figure 7.4. Transposition of melody from one key to another

The transformations demonstrated in Figures 7.1, 7.2 (a), or in jokes have nothing to do with numbers and calculations. While shift in time or operations of symmetry demonstrated in Figures 6.4 and 6.5,—as well as the change of the frequency of the sound—can be expressed mathematically, the case with the jokes seems to be far off the domain of natural sciences. Modern physics, however, understands symmetry with a much wider perspective than that of a traditional view stemming from antiquity.

> Physicists describe these two properties of physical laws—that they do not depend on when or where you use them—as *symmetries* of nature. By this usage, physicists mean that nature treats every moment in time and every location in space identically—symmetrically—by ensuring that the same fundamental laws are in operation.
>
> (*B. Greene, 1999,p. 169*)

Symmetry is defined as "a property of a physical system that does not change when the system is transformed in some manner" (*B. Greene, 1999, p. 423*). This manner is not necessarily movement in space; it can be anything.

The question arises, therefore, whether a transformation should necessarily have a mathematical expression.

In fact, the translation of a joke from one medium to another is not what would have been considered mathematics in the nineteenth century. Today, however, mathematics also embraces algorithms, i.e., systems of clearly defined instructions of any kind, even with elements of randomness and uncertainty.

Consider, for example, another operation in preserving the tune: musical transcription from one instrument—a cello, to another—a trombone, or even a transcription of Bach's Toccata

and Fugue in D Minor from organ to orchestra. The short instruction to a musician would be: "play this on the trombone." The long and explicit instruction would include everything concerning the art of playing both instruments. Electronic musical instruments can do the same using built-in algorithms.

There is little need to argue whether the hardly definable translation of a pattern from one culture to another should be considered mathematics; the body of mathematics is changing before our eyes. Entrusted to the massive power of computers, more and more often simulation takes precedence over mathematical inference on a piece of paper or blackboard. Classical mathematics was the drive of mathematicians to test the limits of their imaginative power and to see what heights the human mind could achieve, while the brutal force of computing is commonly assigned to do what the human mind is powerless to accomplish, limited by its very nature.

Computers provide visual examples of continuous transformation within simple screen savers in the form of a moving curve or polygon, (see Figure 7.5). They preserve the property of being a polygon, and the number of edges, but nothing else. The curves are all closed and smooth.

Someone with an Aristotelian frame of mind would quickly notice a possible parallel (pattern!) between geometry and the future science of history that could be tailored by computers from the fabric of facts (see Chapter 27, *History and Computers*). We will not go that far at this point. It is hard to ignore that what some people expected to happen in the future—for example, the end of the world—has never happened, while that which has really happened on earth no one could have foreseen.
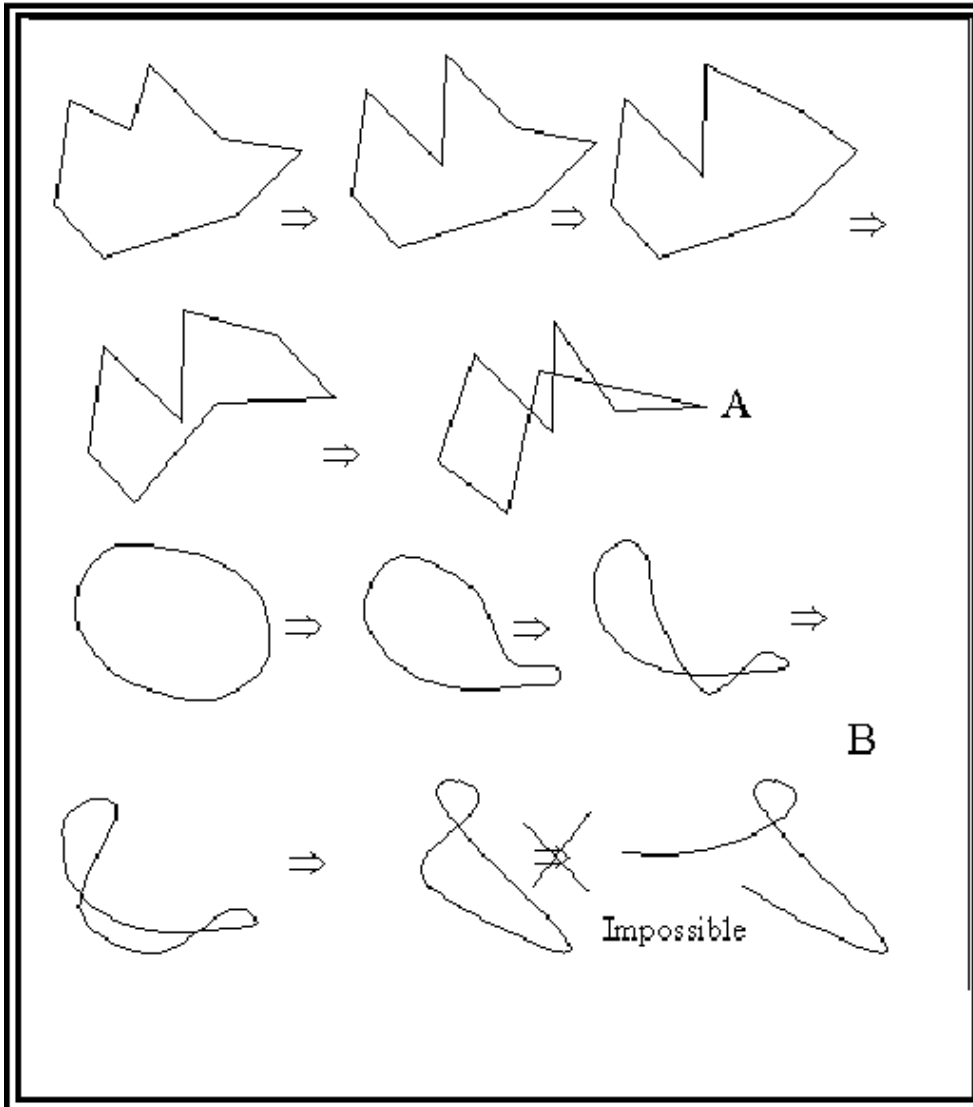
Figure 7.5 Transformations in Screen Savers

Finally, consider the following example:

It was in the 1180s that Japan was first ruled, not by the emperor but by a warrior chief

called a shogun (literally, leader of the army). With some interruptions and interregnums,

this rule by the strongest became the normal pattern. Such is the weakness of heredity

kingship: even with the help of divine ancestry, a dynasty is hard-put to maintain

competence indefinitely. Weak genes, bad marriages, whatever: strong men, mayors of

the palace, will rise to power and sooner or later oust the legitimate monarch.

So it was in medieval France, where the Carolingians displaced the

Merovingians and were pushed aside in turn by the usurper Capetians. In Japan,

however, the solution was not to dethrone and expunge the dynasty but to immure it.

(*Landes, 1998, p. 371*)

The transformation here is a jump from Medieval Japan to Medieval France on the

second generation time machine of H.G. Wells, capable of moving in both time and space. What

is preserved is the *pattern* of the rule of the strongest, with a slight deformation concerning the

means, not the ends.

To summarize, there is a great variance of changes falling under the notion of

transformation, deformation, or operation while clearly leaving something unchanged. Both the

change and the permanence are sometimes hopelessly difficult to define. But the changes that

leave something unchanged constitute one of the most important mathematical subjects that we

shall discuss in the next chapter.

8. Groups

Deformations and symmetry operations with triangles point to another important field of mathematics, reaching far beyond geometrical figures.

The concept of deformation or, more general, transformation, or, even more general, operation, attracted a lot of mathematical attention and is the subject of group theory.

The founder of group theory, Évariste Galois (1811-1832) tried in vain to publish his discovery. On the eve of a duel he wrote notes about his work and was killed next day at the age of twenty-one.
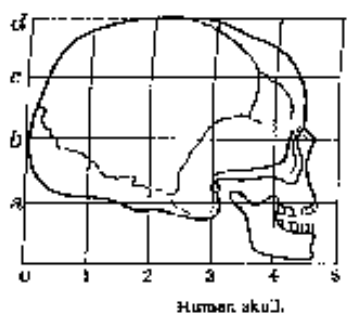
One of the pioneers in exporting the ideas of group theory to the world outside classical mathematics was D'Arcy Thompson, author of the influential and widely quoted book *On Growth and Form*. He thus explained the concept of representing a property by a deformation preserving this property:

This process of comparison, of recognizing in one form a definite permutation or *deformation* of another, apart altogether from a precise and adequate understanding of the original "type" or standard of comparison, lies within the immediate province of mathematics, and finds its solution in the elementary use of a certain method of the mathematician. This method is the Method of Coordinates, on which is based the Theory of Transformations . . . which is part of the Theory of Groups (Thompson, 1961).

Figure 8.1 illustrates his idea. The shape of the scull of a primate is the property in question. We start with any primate and use the shape of its scull as a *template*, i.e., a selected starting point. We can obtain any other scull shape by deforming the template while preserving its topology. Moreover, as follows from the concept, we can infer the scull shapes of primates that have never existed and, by employing a template with a different topology, we could infer entirely new species and families. Concerning the soft tissues, such details as ears, eye sockets, etc., have their own *groups* of transformations, so that we can fantasize over the shape of an eye and overall appearance.

Scores of sci-fi movies and animations, for example *Star Wars*, old and new, show various aliens and creatures that look very much unlike our earth forms or their hybrids with inanimate things. If we look closer, however, all we can see is a deformation of the human form. This is the only template available to us without the actual contact with other worlds. If an artist invents something completely out of this world, the viewer may not even recognize it as a form of life.

The computer-generated aliens undergo further transformations that make them turn and move around without losing the identity.

As far as the triangles are concerned, it means that we can define the property of "triangularity" through a description of a deformation or symmetry operation that preserves this property, for example, stretching in any direction.

Group theory is a basic component of mathematical apparatus of pattern theory. We could do without it in our treatment of history, but it would not be fair: humanities owe a considerable debt to group theory which inspired the entire movement of structuralism that swept large areas of humanities in most of the twentieth century.

The structuralist movement posed the following question. Can we define persistent cultural and historical phenomena not only by their description but also by transforming, deforming, and translating them through times, spaces, and cultures? While usually we perceive such phenomena as singular and distinct, the structuralist idea was to turn from their uniqueness to their ordinariness as members of a class. It was a typical pattern view down through the roof, as in Figure 5.4.

Figure 8.1. Deformation of scull shape. From Thompson (1961): (a) human, (b) chimpanzee, and (c) baboon

Something like that was done in 1869 by Dmitry Mendeleyev who discovered a way to organize many dozens of unique chemical elements in a system so robust that it predicted new

and yet undiscovered elements. Instead of explaining properties of each element—it became possible only century later—he showed how such properties could be derived from all the rest of elements in his system.

The idea of structure borrowed from the group theory invaded anthropology, linguistic, sociology, and other humanities, and, as any aggressive invader, created a resistance movement in the competitive atmosphere of humanities.

Groups, like graphs and other mathematical creations, are abstract objects. Plato would certainly love them and add to his list of perfect ideas.

To discuss the difference between graphs and groups could help understand both. As we know, graphs are completely defined by a set of elements and binary relations between them. An example is the square table of who is acquainted with whom (relation), added to the list (set) of guests at a wedding reception. For a group we need a set of elements, too, and there are binary relations as well, but their nature is radically different from that between the points of the graph: they are transformations, otherwise called operations.

Figure 8.2 reflects the remarkable difference, as well as distant kinship, between groups and graphs. Both are binary relations recorded in a square table, but the table for a group (Figure 8.2A) contains not zeros and unities but the same entries that the side bars of the table: elements of the set.

It is easy to draw the graph, Figure 8.2D, from its table, Figure 8.2B, but what can table in Figure 8.2A signify? The elements of a group are operations that convert a pair of elements into a third one.
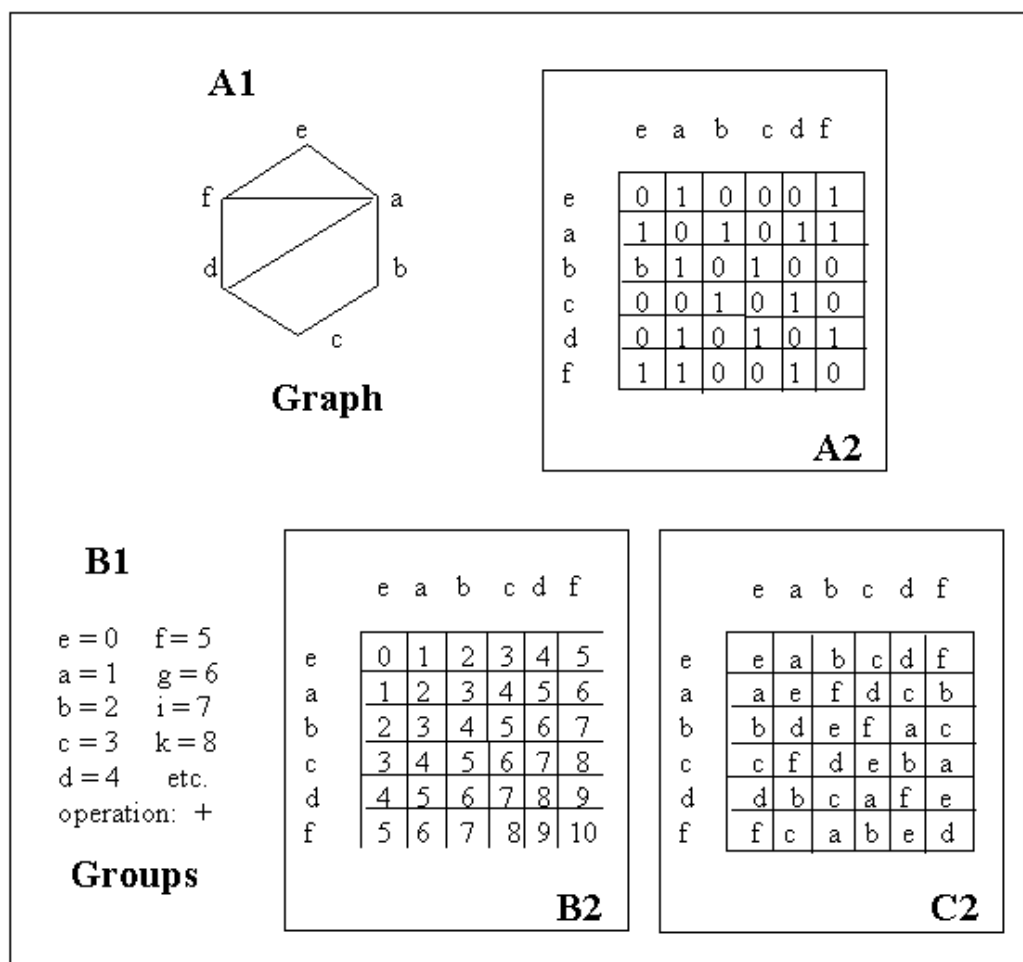
A1

Graph

A2

	e	a	b	c	d	f
e	0	1	0	0	0	1
a	1	0	1	0	1	1
b	b	1	0	1	0	0
c	0	0	1	0	1	0
d	0	1	0	1	0	1
f	1	1	0	0	1	0

B1

e = 0   f = 5
a = 1   g = 6
b = 2   i = 7
c = 3   k = 8
d = 4   etc.
operation: +

Groups

B2

	e	a	b	c	d	f
e	0	1	2	3	4	5
a	1	2	3	4	5	6
b	2	3	4	5	6	7
c	3	4	5	6	7	8
d	4	5	6	7	8	9
f	5	6	7	8	9	10

C2

	e	a	b	c	d	f
e	e	a	b	c	d	f
a	a	e	f	d	c	b
b	b	d	e	f	a	c
c	c	f	d	e	b	a
d	d	b	c	a	f	e
f	f	c	a	b	e	d

Figure 8.2 . Graph (A) and group (B) as tables . Group C2 is permutation group, see Figure 8.4

As an example of group, we take a set of all integers (positive as well as negative) and operation of addition. Whatever number we add to another number, for example, 2+3=5 or 4+123=127, the result will be a third number, which is also an integer and member of the "integrity" club. Integers, therefore, form *a group* with infinite number of elements *under the*

operation of addition. Multiplication also covers a group of integers, but division does not.

Fraction 2/3 has no integrity to be admitted to the club of integers.

More generally, we should think about groups as an operation of combination (denoted as •) of two elements **a** and **b**, so that the result is also an element: **a** • **b** = **c**.

In the upper half of Figure 8.2 we see graph **A1** with six elements **a** to **f** . Table **A2** contains the information about the way they are connected.

In the lower half of Figure 8.2 we see positive integers from 0 to infinity (**B1**) and part of the table representing the group of positive integers under operation of addition. The table is infinite and its extension would accommodate all the positive integers.

Table **C2** looks different. Its five entries are all closed on themselves. What could the letters **a** to **f** signify?

Let us take a simple example: moving a glass on a bare table in a certain direction and at a certain distance. All such movements of the glass from one point to another form a group under the operation of displacement because any two consecutive displacement **a** and **b** are equivalent to a certain displacement **c** (Figure 8.3D).

This group tells us something about the structure of the Euclidean space.
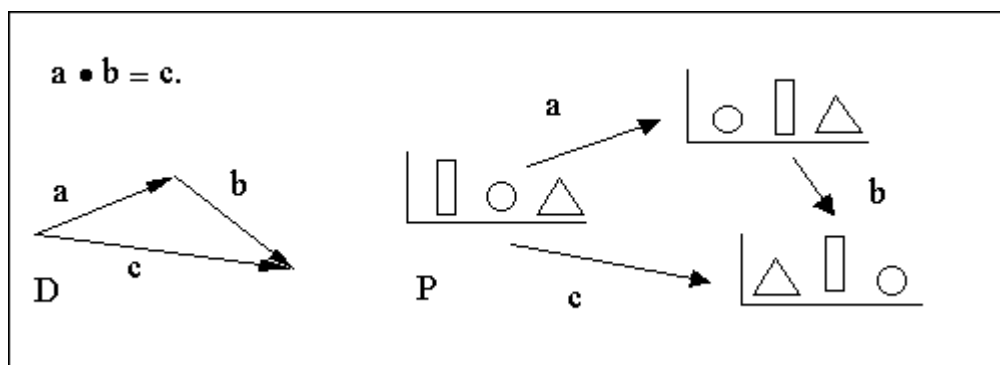

Figure 8.3. Operations of displacement (D) and permutation (P) : two consecutive operations a and b are equivalent to operation c

Figure 8.3 presents a completely different operation of permutation, i.e., rearrangement of a sequence of objects regardless of their exact position in space. Coming back to wedding reception, it can be exemplified by changing the sitting order of guests at a table.

There are additional requirements for a group:

1. There is an identity element **e**, so that **a** • **e** = **a**, i. e., the element, that does not change anything, like zero in the addition of integers.

2. For each element **a** there is an inverse element –**a** so that **a** • –**a** = **e**. For example, adding and then subtracting the same number or moving the glass and returning back to the starting point does not change anything.

3. **a** • (**b** • **c**) = (**a** • **b**) • **c**. This means that we can combine operations in different ways with the same result.

This is true for addition, but not for subtraction:

(5 - 4) - 3 is not equal to 5 - (4 - 3).

4. For a class of groups called Abelian, **a** • **b** = **b** • **a**, which means approximately that Tom Sawyer could paint the fence left to right or right to left with equal result.

We put the fence here to emphasize that the notion of operation is much wide than a mathematical operation in a common sense: it can be anything.

Another couple of examples are Figures 6.4 and 6.5 where triangles form groups under operations of translation, rotation, stretching, and some types of symmetry. All those transformations preserve the property of being a triangle, and some of them, like rotation, translation, and symmetry, preserve the property of being a particular triangle.

We do not need any geometrical imagery for a transformation and instead of triangles we can operate with their vertices **A**, **B**, and **C**, rearranging them, for example:

ABC→(transformation **e**)→ **ABC** →(transformation **a**)→

A C B →(transformation **b**)→ **B C A**→(transformation **c**)→ **C B A** → ... see Figure 8.4.
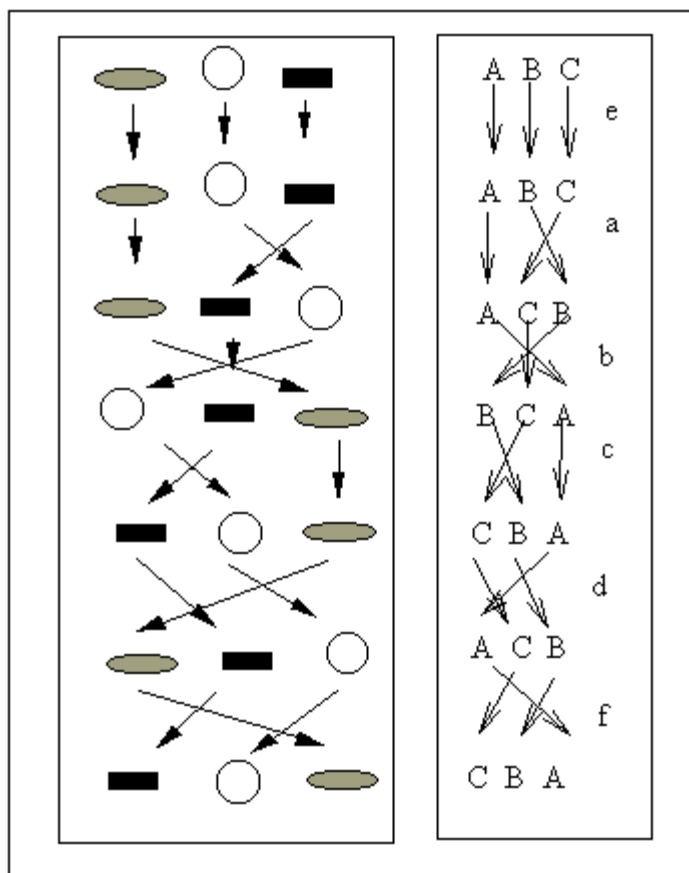
Transformations **e**, **a** - **d** form a group, where **a • a • a = e** and **a • b • c • d = a**

Instead of letters, we can permute any objects, as the left part of the figure shows. Regardless of the nature of objects, the group remains the same.

Figure 8.4 gives the meaning of the elements a to f in table **C2** of Figure 8.2.

While graphs can be easily interpreted and illustrated with examples from everyday life, it is more difficult to do with groups. Groups may show some properties of the world that are hidden and it can take some effort to uncover them. Obviously, groups of translation, rotation, and symmetry reflect those properties of the world that allow us to rearrange furniture in the room without destroying it, while stretching is something we can do with only few things made of latex.

Figure 8.5 shows the so-called Klein group illustrated with four different sets of elements in the same diagram. The lines show operations that transform one element into another.

Figure 8.4. Permutations

Example 1. Elements: shape and color: square, circle, black, white.

Operations:

a. **e** (no change).

b. Changing shape from square into circle and back.

c. Changing color.

d. Changing both shape and color, for example, turning black square into white circle.

Example 2. French language: ami, amie, amis, amies.

1. Changing gender (ami → amie)

2. Changing number (ami → amis)

3. Changing both gender and number (ami → amies).

Example 3. Arithmetic: plus, minus, inverse, unchanged.

1. Changing sign x → −x

2. Inverting x → 1/x

3. Changing sign and inverting opposite.

Example 4. Permutations:

1. Switching pairs of letter: abcd → cdab

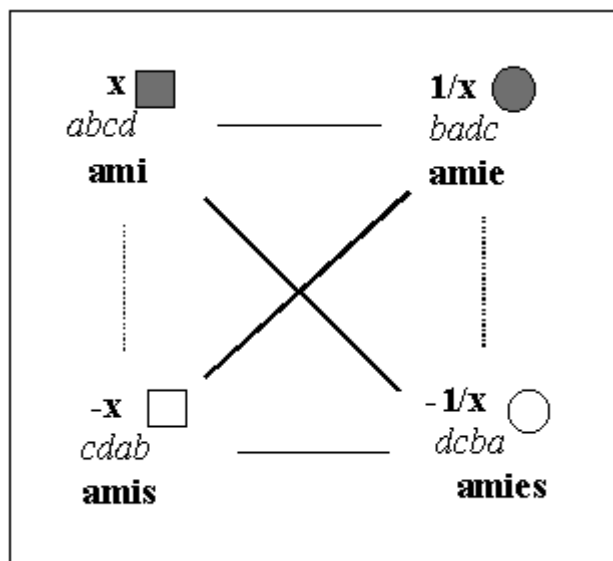2. Switching letters inside pairs abcd → badc

3. both

Figure 8.5. The Klein Group

Example 5. Experiments with trousers

(Budden, 1072. p. 131).

X : turn the trousers back to front

Y : inside out

Z : **X,** then **Y**

The following 4 x 4 table contains the results of "multiplication", i.e., two combined elements.

	e	X	Y	Z
e	e	X	Y	Z
X	X	e	Z	Y
Y	Y	Z	e	X
Z	Z	Y	X	e

All of them have the same structure of the Klein group.

Now we can take a fresh look at the Hippocratic medicine (Figures 2.2, 2.4, and table 2.1). The four humors form the Klein group, as Figure 8.6 shows. Here change of wetness/dryness and temperature are basic elementary operations of the group.
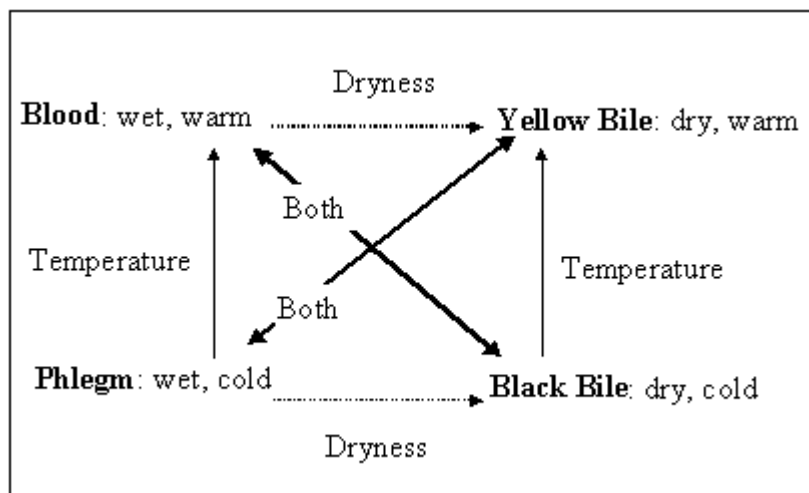
Figure 8.6. "Hippocratic" group

In general, if **S** is a set of elements of a group **G**, **S** = {**a,b,c**, ...}, and if all elements of **G** can be expressed as products involving only the elements of **S** (and their inverses), then we call the elements of **S** generators of a group.

That was the idea of structure as system of relationship that was borrowed by classical structuralism of Claude Lévi-Strauss from mathematics. Structure in structuralist sociology and anthropology consists of binary relations called oppositions. Structure is a combination of relations and it can be traced trough various cultures.

Figure 8.7 summarizes basic relations between relatives in five societies. Plus means positive, respectable, or tender relationship, while minus denotes antagonism. Levi-Strauss noted that in each system the four relations fell into two pair of oppositions, and there were exactly two positive and two negative relations in each system.

The structure of kinship, therefore, is not a particular distribution of relationships in a family but the statement that out of four relations, husband—wife, wife—(her)brother, (her)brother—(her)son, and (her)son—(her)husband, two are positive and two are negative. This pattern turns to be stable.

Relation	Tribe				
	Trobriand	Cherkess	Tonga	Lake Kubuta	Siuai
Husband-Wife	+	−	+	−	−
Wife-Brother	−	+	−	+	+
Father-Son	+	−	−	+	+
Maternal Uncle-nephew	−	+	+	−	−

Figure 8.7. Structures of kinship (Levi-Strausse)

We find a somewhat similar structure in literature, an evolutionary successor of mythology, along with history. Consider the relations between protagonists of *Romeo and Juliet* and *Westside Story*, Figure 8.8
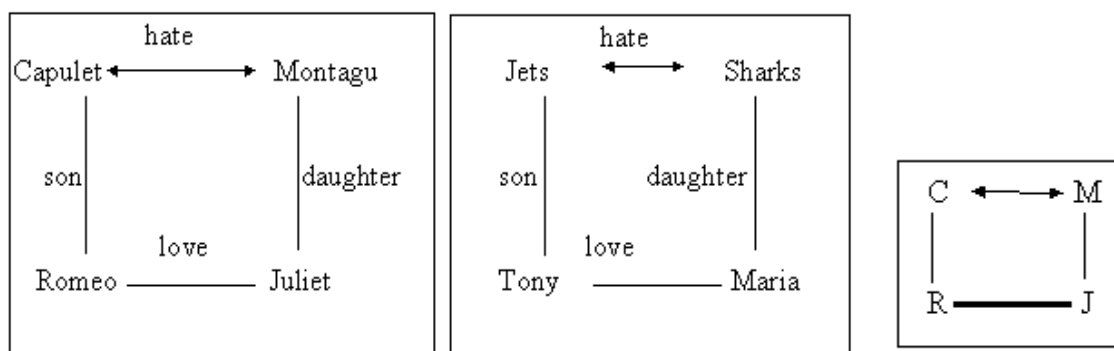

Figure 8.8 . The pattern of tragedy

Here, however, we have three positive relations and one negative. As result, the structure is tragically unstable.

The final concept of structure in structuralism was what can otherwise be called invariance—something that persists through various changes, real or imaginary, like browsing

through various historical times and locations. In other words, it is a property of a system that is not that conspicuous on the surface. A physicist would call it symmetry. Group, however, is not the only mathematical description of structure. In fact, all mathematics is about structures, invariances, and regularities, of which group is only one example.

Graphs and groups represent two mathematical concepts of structure. Graphs embody the idea of structure as an arrangement of constituents, some of which are connected and some are not. A graph cannot portray a shape, such as human face, but it may serve as a starting system, as simple circles and lines for children learning to draw.

The graph is an embodiment of chemical and architectural concept of structure. The group idea of structure is less visual. In essence, it is the hidden "physical" order of things that could be explored by transforming one thing into another. We cannot even ask, however, why one structure changes for another on its own unless there is an additional principle similar to a physical law.   Without it any structure is as good as any other.

The world of groups is the world of common sense, without miracles, catastrophic losses, and staggering innovations, the predictable world of mechanical motion, solid objects, and conservative properties. The world where transformations form groups brings no surprises. It is the world of individual creations of the mind comparable with a collection of crystals, in a museum-like atmosphere. Groups are means of classification rather than discovery.

The group definition of order does not tell us what the order is unless we have at least one example (template). If so, we can change it and show what is constant during the changes.

NOTE: The wireframe shape, used, for example, in computer animation, is a combination of a metric 3D graph-like structure with a group of its transformations consistent of stretching and compressing of arcs. The movements

of the dinosaur form a group although it, probably, cannot be described analytically. The transformations preserve the graph, but not the metrics.

When mathematical ideas of structure were introduced into humanities, the next step was to tie the stability of a structure to the internal tension created by negative relationships and compensated by affinities. By looking at the individual graph of relations we could in principle make a transition to problems of dynamics. The fundamental idea of sociology, anthropology, and chemistry was to evaluate the overall stability of a structure by scanning its elements. It is essentially the same process as appraisal of real estate: summary of all drawbacks and advantages of a building. This idea of additivity of positive and negative increments of structural elements into an overall non-structural value is, therefore, something very general and it opens a way from classification to dinamics.

In case of Romeo and Juliet, we could ask what could happen in this situation.

There are two possible outcomes:

(1) **R-J** breaks up or (2) **C-M** turns positive.

Outcome (1) happens if **C-R** and **M-J** are strong (if they are not, they could be broken). Outcome (2) happens if **R** and **J** can produce enough energy to compensate for the repulsion of **C** and **M**. Obviously, (2) is out of question. We can see, however, how a multitude of plots grows out of the square. **R** can abduct **J**, for example. **R** and **J** can use an outside source of energy, like magic. They can even call for a foreign invasion.

The conclusion is that this situation is equivalent to the superposition of two opposite forces on **R** and **J**, which causes their elimination, the ultimate outcome of a tragic human conflict. The author resolves the insoluble situation by death.

The paradigm of structure as group of transformations, however, misses an essential property of real life. For example, the group of transformations of the wireframe describes a moving dinosaur but has nothing to do with the prediction whether the beast will be killed or, on the contrary, happily feast on a human. To put it differently, we can discuss the differences between a Neanderthal man and *Homo Sapiens* but not the evolution of primates from the first mammals.

The quest of cultural structuralism for a social physics was not finished. The harsh schematization and formalism of structural approach contradicted the richness and complexity of real life, which could not be boxed in the simplicity of the Klein group and its triangles. The lack of evolutionary dimension and the absence of time from the picture was another shortcoming. The idea was brilliant but too much ahead of the time.

The main threat to structuralism came not from internal difficulties, however, but from the explosion and outside invasion of postmodernism. Ironically, postmodernism, inherited the structural paradigm of structuralism and, following the principle of oppositions, simply reversed the priorities: instead of the search for regularities, invariances, and patterns, the attention of humanities was directed to margins, deviations, irregularities, and fringe. Paradoxically, the structural paradigm survived. As Crane Brinton noted, revolutions always change less than they leave unchanged.

History of structuralist ideas that independently originated in sociology is an interesting subject, from both theoretical and personal perspective, but sociology is an immense subject, in many aspects similar to chemistry, and neither one nor the other can be reviewed here.

Note that the typical features of the primate scull can be described directly, without any coordinates. It was the instinctive belief that mathematics could reveal to us something lost

among words that guided the first enthusiasts of mathematization of humanities. Note also that ideas of group theory are basically non-numerical, which facilitates their export and reimplantation on alien soil. Note also that as Columbus did not find pepper, cloves, and nutmeg in the "India" he discovered, structuralism did not bring the intellectual spices for everybody's use as it promised, either. Yet the intellectual sailing in humanitarian seas by the mathematical winds is far from over.

This poses the question: what do we need to look for in our attempts to understand the world in most general mathematical terms? And what is there to understand?

In the next chapter we shall give the tired reader some verbal potion to ease the mathematical seasickness.

9. To understand the world

The quest for knowledge has been driven by many forces, one of which is the craving for power. Knowledge can be used to control the future, to influence the behavior of the enemy, perhaps even the gods, it can be exploited to improve one's health or success in love, it can make the clever rich and the adventurous victorious. To achieve this, princes employed astrologers to study the motion of the planets and republics had asked augurs to examine the entrails of animals before important decisions were made.

The curious mind searches knowledge for its own sake, for the pleasure of discovery, to find beauty in order, to find truth. When Pythagoras had discovered the theorem to be named after him, his happiness was so great that he ordered a hecatomb of oxen to be sacrificed; little did he anticipate the future practical use of his lovely find. Faraday's study of electricity was so obviously useless that, when the chancellor of the Exchequer asked what it would be good for, Faraday took refuge in the riposte: "So that you, Sir, can impose a tax on it!" Closer to our times,

Sir Ernest Rutherford, the founder of atomic and nuclear physics, was certain that his theory would never have practical application.

Today science depends on money and the money is hard to get if the scientists do not show the practical importance of their work, whether true or imaginary. The scientist cannot refer to Democritus who said, "It is not in strength of body nor in gold that men find happiness, but in uprightness and in fullness of understanding." The scientist usually follows the example of Faraday. Science and politics proclaim themselves extremes, but the extremes meet.

Whatever motivates the search for knowledge, the explorer must start from a belief that knowledge is possible and that the world can be understood. An underlying assumption, perhaps made tacitly, must be the tenet that there is some order hidden under what at first seems like chaos. As Albert Einstein noted, "The most remarkable fact about the world is that it can be understood."

For millennia people managed to understand the world around and survive in a hostile environment without literacy, education, and any notion of order and chaos. Animals do the hard business of survival every day with even scarcer educational background. What we intend to do here is to understand some aspects of understanding itself. We cannot do that by just throwing words around, and since we mentioned order and chaos we need to give some idea of what we mean by that.

In the twentieth century, chaos stepped into the line-up of the most fundamental scientific concepts. The inconvenient thing about chaos, however, is that it escapes universal definitions and is regarded as absence of order. Naturally, order is absence of chaos. Each field of science has its own idea of what chaos is. For our purposes we regard the ultimate chaos as a complete

absence of links, bonds, and relations between separate components of the world. As soon as we notice such links, we begin to see the underlying order of the world.

In fact, this view is not too far from the physical perception of chaos of molecular movement as the absence of *interaction* between individual particles of gas moving completely independently of each other. The broader view implies that there are stable particles, components, blocks, units, cells, atoms, primitives, etc., in any object, and chaos means that they are not connected in any way, whether they move or not.

We can get some taste of static chaos from a text in a totally unfamiliar language, especially, in a non-Latin alphabet. We simply cannot comprehend anything in a Chinese, Hebrew, or Hindi text, unless we know the language, and neither can we imagine how it sounds.

We are hardly capable of imagining a larger world without relations and connections. If we look at the string of alien characters, we can in most cases (it is not easy in Arabic) split the line into separate characters, identify their sequence, recognize some identical characters, and even standard elements of Chinese characters, not knowing what they mean. When we look at a picture, we immediately distinguish between left and right, top and bottom, close and distant details, etc. When we want to walk across a road, we look for the incoming cars because there is a link between the car and danger.

Animals can probably read the book of nature better than we, but their world may have no links with our world. Each spring and fall, driving on country roads, we can see carcasses of small animals hit by cars. Despite their excellence in the art of survival, a squirrel or a raccoon have no links with the small but fast growing object looking like no familiar predator. The lethal experience does not give the animal a second chance to establish the relation between the object and danger. The stretch of the highway is for them like a line of text in an exotic language for us.

On the contrary, the sight of the family car excites the dog anticipating an enjoyable picnic because of a *regular* experience.

How can we see which of many objects, facts, circumstances, and changes are connected? We leave this exciting question for cognitive science to answer. All we know is that it has been presenting a constant challenge for schoolchildren as well as to distinguished scientists.

Now we have a powerful scientific apparatus for discovering the regularities of the world, from the link between nutrients and health to the dependence of economics on political decisions—none of them faultless. If people had a picture of nature long before any science, we cannot blame them for a strange fantasy or a ridiculous blunder. It may be very difficult to find a connection between events even in somebody's own life, not to mention the events involving large numbers of people, which is exactly the subject of history.

One can only speculate how early humans began to observe order in Nature, but one of the first discoveries was likely the regularity of the changing seasons, how summer is followed by fall, day by night, how the length of the day increases and decreases in a periodic manner that makes it possible to design calendars. Ancient astronomical observatories all over the world witnessed the dawn of natural science, of course intermingled with magic, beginning a long history of uneasy coexistence with religion, but also of undisputed practicality for agriculture and commerce.

It is the connection between two disparate entities that we call an atom of knowledge. What has no link to something else is either chaos or it does not exist. Five thousand years ago people in Mesopotamia went to extremes, as it seems to us now, to establish such links between

"before" and "after"—what modern chemists, palm readers, stockholders, and political observers do everyday for living.

> If the north wind sweeps the face of heaven until the appearance of the new moon: the harvest will be abundant.
> If a man's chest-hair curls upwards: he will become a slave.
> If a man has a flushed face and his right eye sticks out: he will be devoured by dogs far from his house.
> If the gallbladder (of the sacrificial sheep) is stripped of the hepatic duct: the army of the king will suffer from thirst during a military campaign (Bottéro, 1992, p. 129).

Time is conspicuously absent from the predictions. Hodja Nasreddin, the legendary sage, trickster, and preacher of Central Asian folklore, was said to promise fierce Tamerlane to teach his donkey to read in twelve years. When asked by friends how could he risk his life so recklessly, he said "In twelve years either Tamerlane, or the donkey, or myself will be dead."

10. From Augustus to Nero

We have already met the first points and lines which we are going to make work for history. By no means we claim to be the pioneers in this field, however,

Graphs have a common, although less illuminating, presence in works of historians. They are often used to show the structure of kinship in royal families, genealogy, and subordination in social institutions. Such graphs seem static, but they can be useful for portraying evolutionary change.

Figure 10.1 contains genealogy of emperor Nero, borrowed, with some modifications, from Grant (1987, p. 255). We have enclosed men in rectangles, women in ellipses, highlighted the names of emperors, and succumbed to the temptation to show how violent death descended on the family of Octavian Augustus.

The chart shows couples (Augustus and Scribonia, Tiberius and Livia, Anthony and Octavia, etc.), their children, and the children of their children. It is not a legitimate mathematical

graph because the lines have junctions. The junction is used as a way to show that the children are connected to their parental couple as a whole and have links to both parents.

The subject of genealogy used to be a serious matter and its differing interpretations were often a reason for starting medieval wars, for example, the Hundred Years' War.
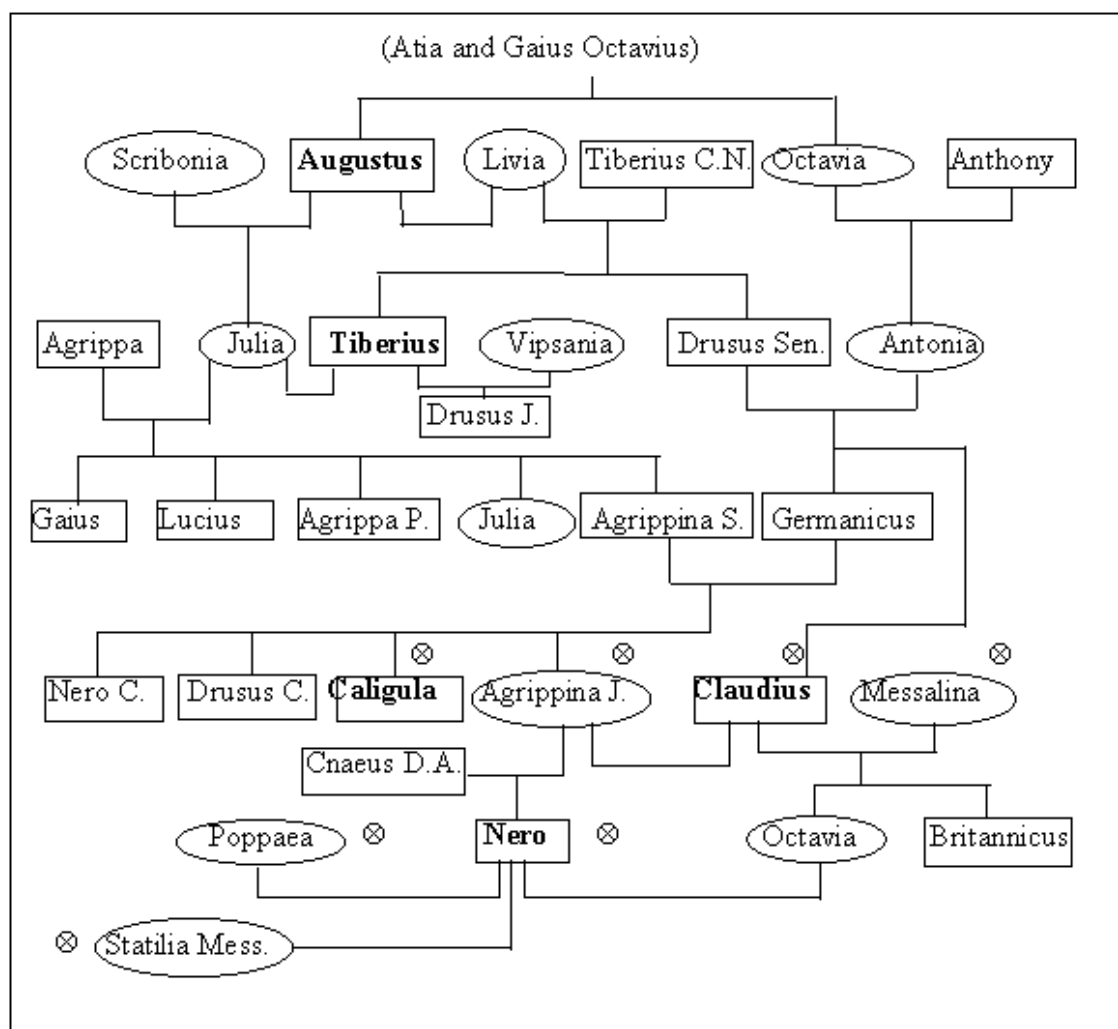

Figure 10.1 . Genealogy from Octavian Augustus to Nero. ⊗ Denotes violent death or suicide

In 1328 King Charles IV of France, the last king of Capetian dynasty, died childless. The question of the succession was by no means clear, see Figure 10.2. This situation has some resemblance with the tragic pattern of Romeo and Juliet: Edward III, the love child of Isabella and Edward II, the descendants of two rival nations, was a destabilizing factor. The War was precipitated by the dispute over the French throne between Edward III of England and Philip VI of France, nephew and cousin of the deceased, respectively. Geographically, the interests of both monarchies clashed in Flanders.

Since the royal genealogy of Europe used to reach far across state borders, it was both the instrument of peace and war, depending on the circumstances. There were periods, for example, after the defeat of Napoleon, when the monarchs cooperated well. Still, from early Middle Ages, in spite of the ongoing royal intermarriage, the history of Europe up to the end of the WWI was a record of wars. We will come back to this question in Chapter 18, *Conflict*.

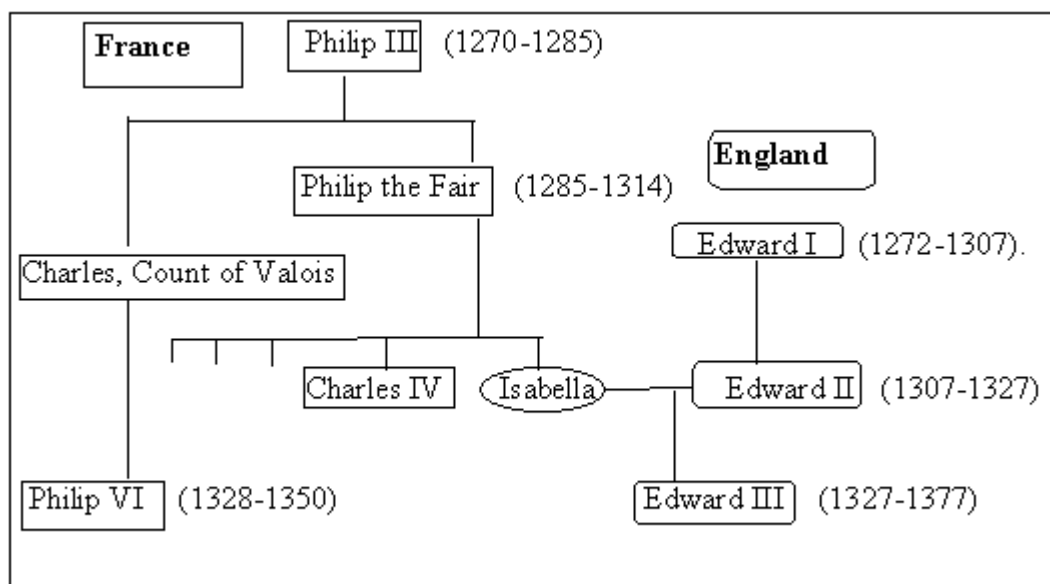Comparing the two historical situations separated by over thousand years, we can clearly

Figure 10.2. Valois and Plantagenets. From McKay (1983), Vol. 1, p. 394).

see the progress of humanity. While murder was the common ancient way to solve problems,

both France and England initially tried to resolve the question of the succession by rational means before resorting to force. The French appealed to a law denying the succession trough a female line, but the English did not accept it. The subsequent hundred years of history of France had their share of insanity and murder. The practice of *appanage* , i.e., giving provinces to all sons of the king, created a constant feud (Brinton, 1967), Vol.2, p. 386).

Genealogies do not seem to attract any significant interest of modern historians, but they commonly illustrate the narrative. We see in them a graphic way to express the link over time between mundane events without much effect for contemporaries but with dramatic consequences in later times. In this sense genealogy is a way to portray the evolutionary change.

In Figure 10.3, we make an attempt to convert the typical genealogical illustration with junctions into a typical graph format with single lines. We mostly preserve the position of the nodes, so that they could be identified by comparison with Figure 10.1. The dots of the emperors are encircled.

Here the square dot means a marital union between the parents that resulted in progeny, the round dot means a person, the in-arrow means spousal bonds, and the out-arrow means a parental bond.

What we can see from the graph is the divergence and subsequent convergence of two lines of kinship, which is an evidence of inbreeding through marriage between relatives. One continuous string of arrows goes from the parents of Augustus to Julia, Agrippina S (Senior). to Aggripina J (Junior)., while the other makes the same connection through Octavia, Antonia, and Germanicus. The shadowed areas indicate the cycles of inbreeding. There are more such cycles in Figure 10.1, but not all of them produced progeny.

Our experiments with genealogy do not look too enlightening: the systems of this kind are inconvenient to portray by graphs. The reason for this is that there are two or more somewhat independent layers of relationship, for example, spousal and paternal. We have a choice,
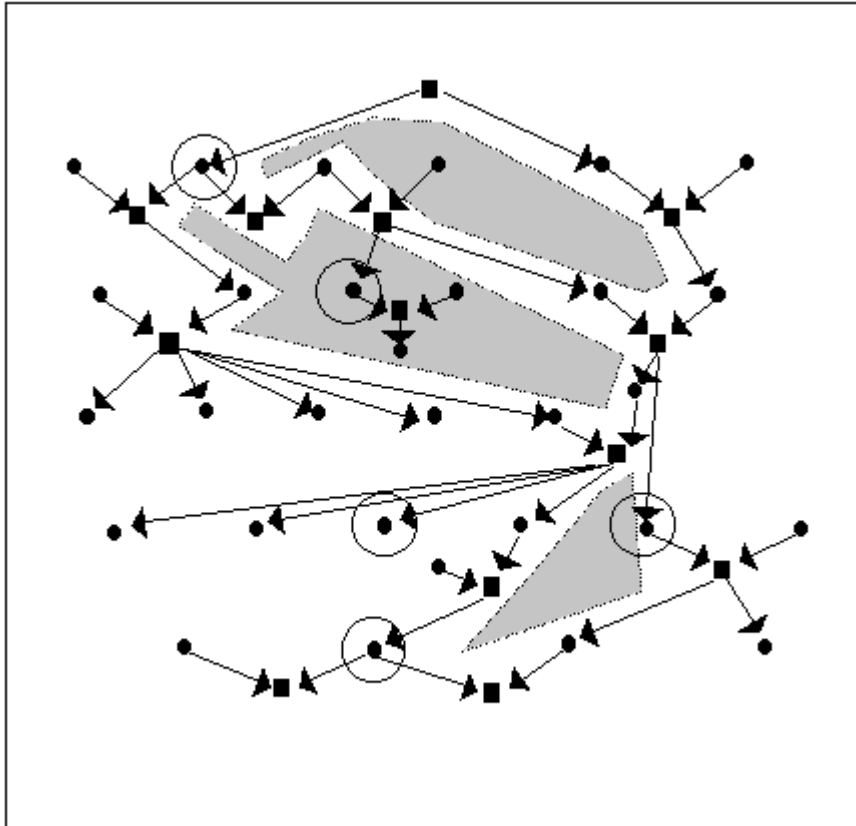

Figure 10.3. Augustus' family as gender-neutral graph. Cycles of kinship are indicated by shadowed areas; emperors encircled; ■ means birth

therefore, to use either two types of arcs or two types of nodes. If we wanted to emphasize brother/sister relationship, we might need a third type of arc. The structure with one node and three arcs is shown in Figure 10.4. Here mother-child and father-child relationships are marked by separate arrows. Figure 10.4 looks even more confusing than Figure 10.3, but it is the matter of convention or habit. The graphs of this kind could be used to trace the kinship links not only

between people and ideas but also between institutions, companies, and products of technology, which is becoming more and more the daily fabric of history.
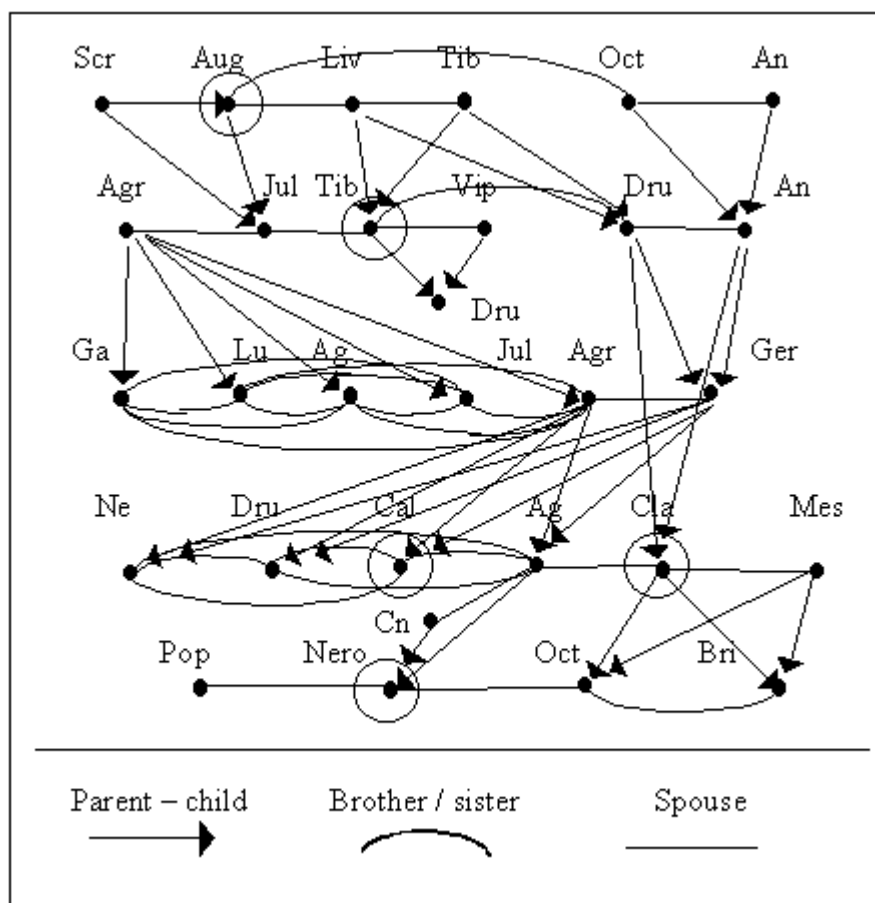

Figure 10.4. Enriched graph of kinship

In some primitive cultures, as we have seen, there are even more important layers of modes of relationship, like uncle—nephew, for example. Simple graphs would be even more confusing in this case. The need to graphically express multi-layered kinship was one of the stimuli for the development of structuralism.

In fact, Figures 10.3 and 10.4 do not add anything to Figure 10.1. We need them only as exercise and illustration to more important matters of *representation of knowledge as structure*. As a preliminary conclusion, even in rather trivial cases knowledge can be very complex, and its representation even more so. In our further exploration in this direction we shall look for ways to simplify complex structures.
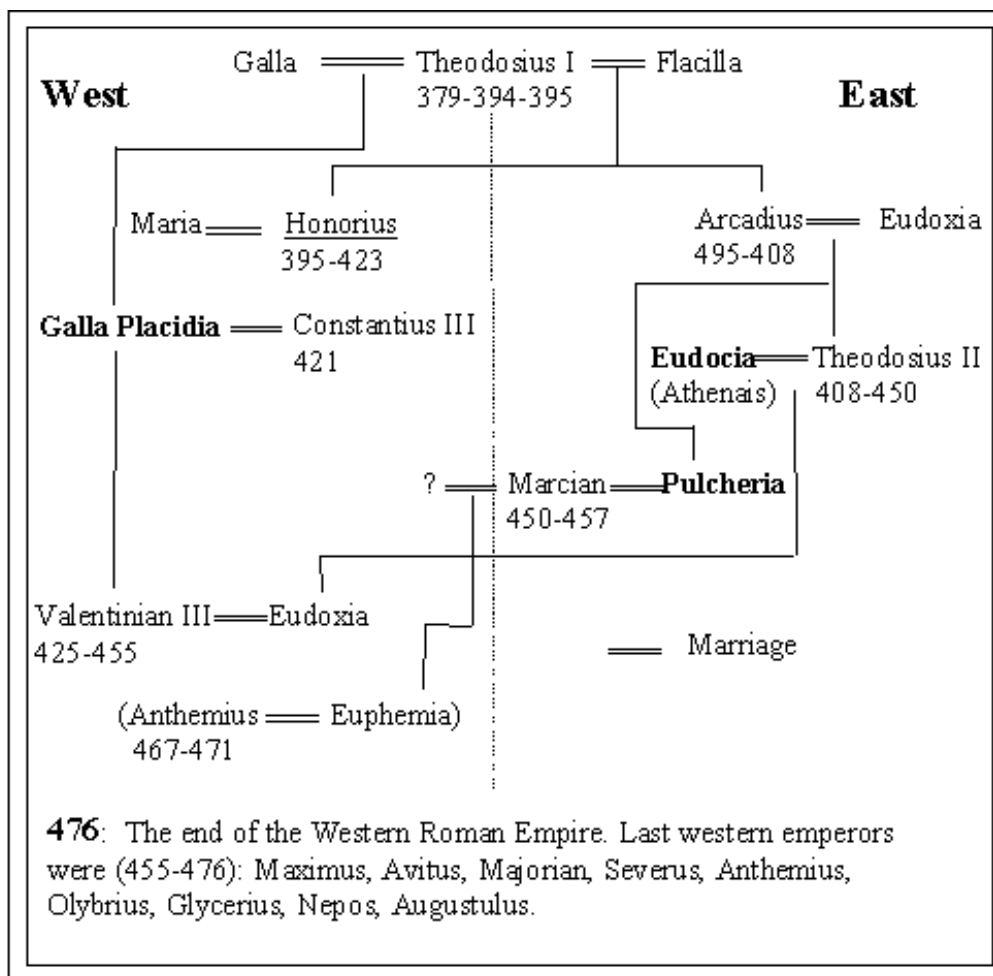

Figure 10.5. Descendants of Theodosius I and the end of the Western Roman Empire.

Normally, genealogy is a branching tree, but it could include cycles when relatives marry, and any culture allows certain minimal blood distance between spouses.

We find another genealogical cycle at the most dramatic moment in Roman history: the end of the Western Roman Empire, Figure 10.5.

Theodosius I was the last emperor to rule both halves of the empire, but he split it between his sons, Arcadius and Honorius. The two lines of inheritance crossed in the marriage of Valentinian III and Eudoxia. Twenty years, nine emperors, and many a colorful detail after Valenitinian III, the Western Empire ceased to exist amidst constant squabble between the halves of the diagram. The names in bold print belong to three women who had the real but disconcerted power during the final act of drama.

The recent rich, forceful, and highly readable book by Randall Collins (1998) is full of diagrams like the one in Figure 10.5. Many of them look even much more complicated than our experiments.

Randall Collins portrays intellectual relations between philosophers, i.e., intellectual genealogy, as points and lines where the points are, obviously, philosophers and lines represent the type of relationship (Figure 10.7). The appearance of the philosopher's name carries some information, too, and the filled areas indicate schools.

Dozens of such diagrams in the books portray the networks of philosophers all around the globe from the very beginnings of philosophy to almost present, creating a captivating three-dimensional picture.

The originality and significance of Randall Collins' work extends far beyond the illustrative apparatus, but we cannot dwell on it here. The only thing we would like to mention is his perception of history of philosophy as a natural process in which philosophers, aware of each other's intellectual presence, compete for the limited space in the focus of attention. For this

picture of an almost biological struggle for existence, the actual content of philosophical theory is quite irrelevant. This kind of rivalry, probably, was fatal for structuralism.

It would be possible to add yet another dimension to the picture by introducing the evolution of philosophy in terms of doctrines, and Collins gives important hints how it could be done. He clearly sees competing philosophical doctrines as combinations of blocks, some of which are simply negations of blocks in rival philosophies.

The use of lines in genealogies helps find the particular system of lines that we call connector. As everywhere throughout this book, line is not a geometrical object but a symbol for
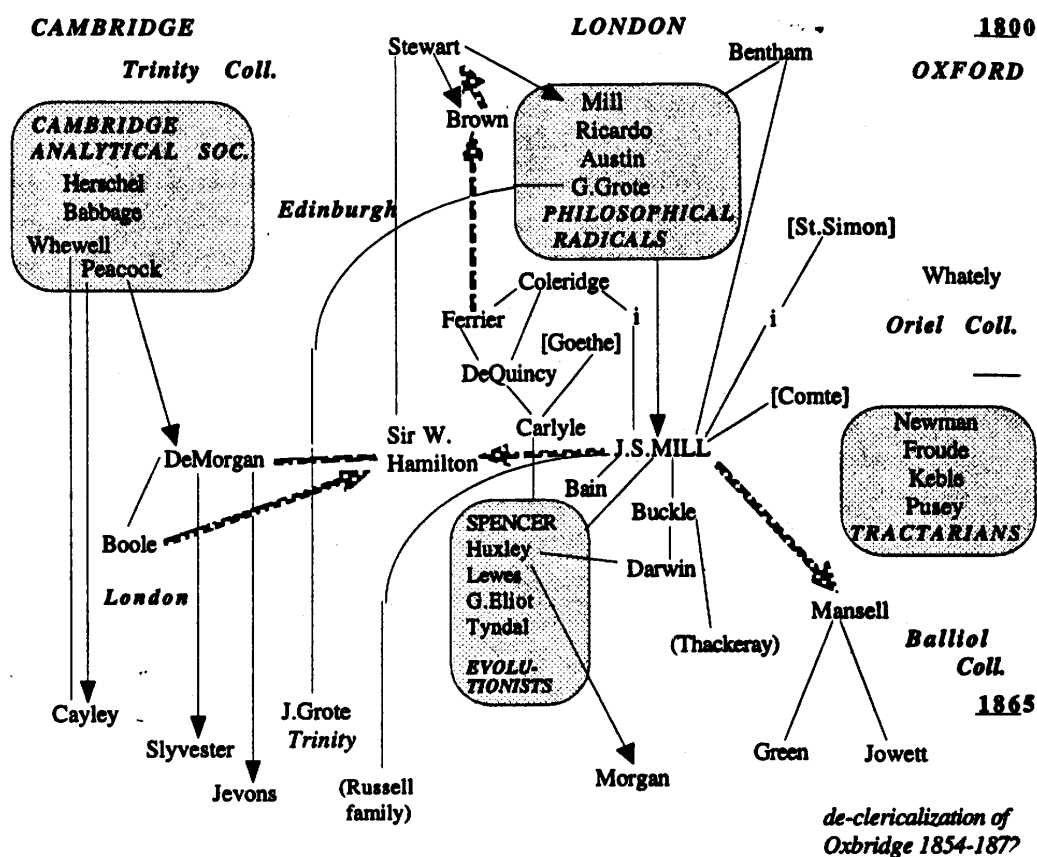

FIGURE 13.2. BRITISH PHILOSOPHERS AND MATHEMATICIANS,
1800–1935: UNIVERSITY REFORM, IDEALIST MOVEMENT,
TRINITY-BLOOMSBURY CIRCLE

Figure 10.6. Sample of a network of philosophers (from Randall Collins)

a much more general binary relation, which can be expressed also in words, tables, circuits, and blocks of program, for example, IF **A** THEN **B**. We can represent knowledge in different ways, and some of them are better than others for particular purposes.
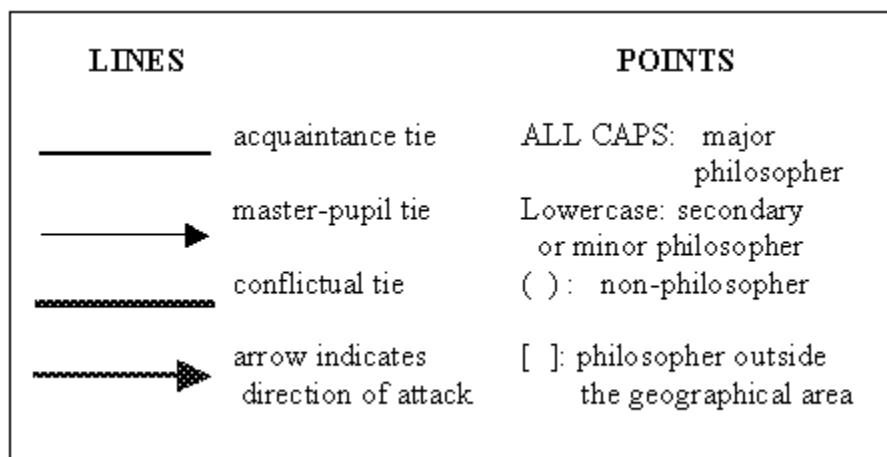
LINES		POINTS
———————	acquaintance tie	ALL CAPS: major philosopher
————————►	master-pupil tie	Lowercase: secondary or minor philosopher
∿∿∿∿∿∿∿∿∿	conflictual tie	( ): non-philosopher
∿∿∿∿∿∿∿►	arrow indicates direction of attack	[ ]: philosopher outside the geographical area

Figure 10.7. Types of points and lines in networks of philosophers (along Randall Collins).

We encounter a problem of similar kind in language, where meaning can be expressed in a variety of forms.

We can simply say: the empire ceased to exist as result of internal problems and external aggression. As an alternative, we can quote Edward Gibbon:

> But the decline of Rome was the natural and inevitable effect of immoderate greatness. Prosperity ripened the principle of decay; the causes of destruction multiplied with the extent of conquest; and as soon as time or accident had removed the artificial supports, the stupendous fabric yielded to the pressure of its own weight (Gibbon, 1946, Vol. 3, Chapter XXXVIII, Part VI).

Some cowboys would say, "If you move I'll shoot you." while others would put it this way: "If you are going to move, sir, you are enjoying the last moments of your life."

11. Syntax and semantics

The beginnings of history come to us in pictures in caves and on rocks. Modern history is written in language. The text of a narrative is a verbal representation of historical knowledge. It is nothing but a string of words equally suitable for communicating the most mundane and transient situations in life of teenagers as well as the decline and fall of Roman Empire. This is the form in which history is recorded, stored, and accessed, and since the reader may be confronted with the question what points and lines could add to it, it seems worth spending some time on language.

What exactly is locked up in words and what can be retrieved from them except the words themselves? This question is usually answered by pointing to meaning.

The study of meaning drew attention of both philosophers and non-philosophers early in the twentieth century and it stimulated the study of structure in general.

Structure is a central concept in such technical areas of human activity as chemistry, construction, and engineering, where it is clearly visible to everybody. If there is an array of

elements or building blocks capable of being combined and connected in many different ways, the properties of the assembly depend on the structure. There is hardly any place for meaning, except for architecture where one may ask about the meaning of a Gothic Cathedral or Eiffel Tower.

The Swiss linguist Ferdinand de Saussure (1857-1913) was especially influential in the structural study of language that later spilled over to many other areas of humanities. Claude Lévi-Strauss, the leading figure in structuralism, never stopped reiterating the influence of Saussure.

No secondary account can be compared with the original *Course of General Linguistics*, by Saussure, the posthumous book published by two of his disciples, basing on lectures that he gave in 1906-1911 and his fragmentary notes (Saussure, 1974). To read this book, is like to read Socrates through Plato's *Dialogues,* as Roy Harris (1987) noted in his critical commentary on the book . This comparison seems two-pronged: first, the book was not written by Saussure himself, second, like the ideas of Socrates conveyed by Plato, it made a powerful lasting impact on humanities as a whole, not just linguistics.

Probably because of the circumstances of its own genesis, the *Course* remains as open to interpretations and heresy as a dark sacred text. It makes an impression of a real primordial soup of ideas. No wonder, an opulent tree of knowledge has grown out of it. Some of the branches originated from the Saussure's ideas, and some, not less fruitful, from their negation: the *Course* combined a plethora of imagination with somewhat dogmatic and categorical tone.

The *Course* seems to be written not just about language but about structure in general. With its examples taken from chess, finances, and biology, it could be about chemistry, as well.

For example, the associative sequence that a word generates has a parallel in homology and general architecture of chemical compounds, Figure 11.1.
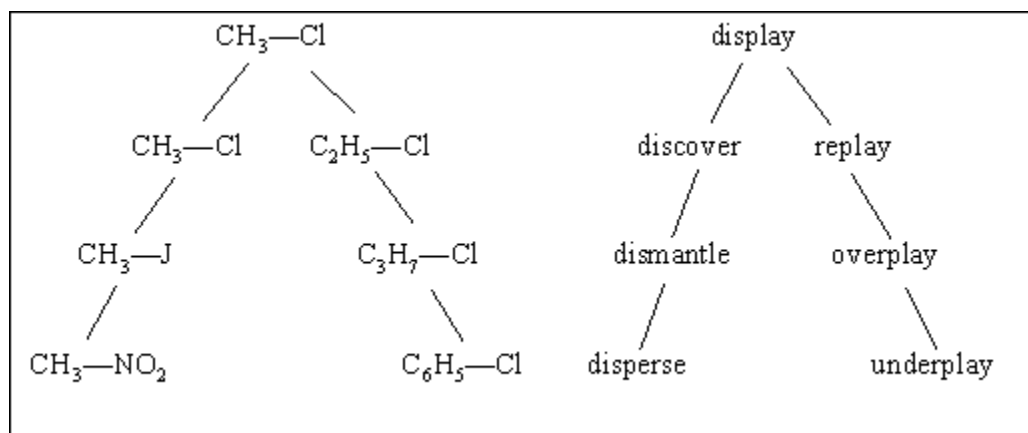

Figure 11.1. Chemical series compared with lexical "associative series" of Saussure

Moreover, it could be written about history, as some remarks in the *Course* confirm. The *Course* regards the language in a strikingly atomistic fashion as a system of units connected with links and changing over times through a sequence of steps. Even more important from our point of view is the observation that the changes in such complex system are usually local and small, leaving the rest unchanged, similar to chemical changes in big molecules. The comparison with DNA mutations comes to mind.

The paradoxical, much misunderstood, and debated conclusion of Saussure that language as system does not change at all seems to contradict the time dimension that he himself granted to language. For us it means that the most abstract patterns of *change* work the same way throughout history. For the chemist it is the same as to say that the laws of chemistry do not change. Basing on his "chemistry" of language, Saussure was able to make some linguistic predictions that were confirmed after his death on the example of Hittite language.

The basic structural idea of linguistics is typically combinatorial: there are three sets of building blocks at different levels: phonetic, syntactic, and semantic. Within a certain language, sounds (phonemes) are distinct entities that combine with each other in certain ways and not in others, words and their parts (morphemes) behave likewise, and deeper under the surface structure, which can be perceived and characterized in all detail, lies a level of concepts (lexemes) that manifests a different kind of structural order, more difficult to define.

What we see on the surface are signs, and they can be easily changed for another set of signs with the same meaning, as chess figures and human figures in Figure 7.2. For example, whether the sentence "A dog chases a cat" is spoken or sung, written in bold typeface or in italic, and even translated into French, it has the same meaning. If we lose a knight from a chess set, we can substitute any small object for it and play chess anyway.

Meaning, therefore, is a pattern, like the melody played in different keys and on different instruments. Life would be much simpler and history more peaceful, however, if meaning was not so often evasive and slippery. It can be distorted not only at translation but even between the speakers of the same language. As the Murphy's law goes, whatever your intent is, somebody will misunderstand you—and we, the authors of this book brace themselves.

The components of meaning are relatively independent. There are meaningless combinations, but meaning can come with time to what was considered meaningless, for example, "This Toyota has a fuel injection" would be meaningless in the twelfth century, and "Alex has two mothers" would be meaningless two decades ago. In other words, the meaning is tied to a contemporary body of knowledge.

There are many brilliant ideas in the *Course*: the concept of analogies, for example, by which the language reproduces itself like living organism through replication. We cannot dwell here on the amazing intellectual creation of Saussure, however, and have to move on. It would suffice to say that Saussure described something more general than a system of linguistics: he offered a very general concept of complex combinatorial structure hold together at any given moment by the static rules and slowly changing from time to time by the rules of dynamic transformations—something we can say about evolution of life and society.
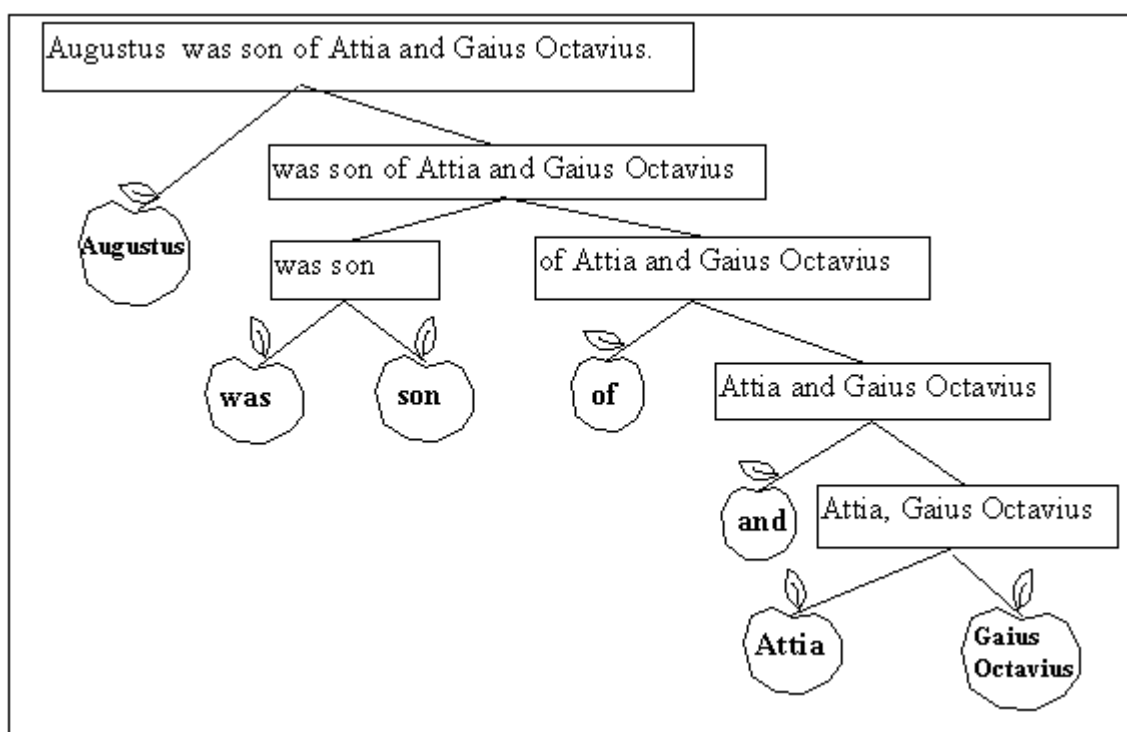

Figure 11.2 . Syntactic tree and its fruit

Structural linguistics, therefore, distinguishes between two layers of structure: grammar (syntax) and meaning (semantics).

For example, part of Figure 10.1 can be described in a simple sentence:

Augustus was son of Attia and Gaius Octavius.

The sentence as seen on the surface is a linear sequence of words. From the point of view of grammar, this sentence has a certain structure described by the chart in Figure 11.2. What is hidden behind the string of words is a branched structure with the actual words hanging from the branches like apples.

Instead of the apples with the names of Augustus and his parents, other names and terms of kinship can be substituted, for example:

John was son of Anne and Bill .

Or:

Rosalind is daughter of Steve and Martha.

The same structure is even more general, and it supports the sentence
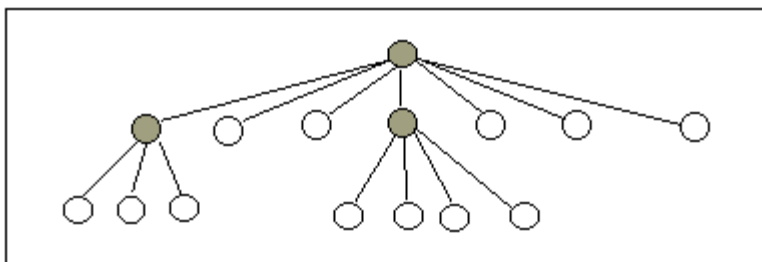
Cats are enemies of rodents and birds .

Figure 11.3 . Sons of Japhet

The genealogy of Chapter 10 of Genesis, which omits women, has the same tree-like connector graph, Figure 11.3.

> The sons of **Japhet**; **Gomer** and Magog, and Madai, and **Javan**, and Tubal, and Meshech, and Tiras.
> And the sons of **Gomer**; Ashkenaz, and Riphat, and Togarmah.

And the sons of **Javan**; Elishah, and Tarshish, Kittim, and Dodanim, etc.

The syntactic structure is indifferent to meaning. The meaning, so to speak, exists in a different dimension. In order to travel in the semantic dimension we do not need to thoroughly follow the grammar.

The meaning of a sentence is commonly portrayed by a part of *semantic network,* a graph where the labeled nodes are connected with arcs symbolizing certain binary relations such as "is mother of," "is a historian," "walk," "have," etc.

We do not need to repeat the words in the chart as we did in Figure 11.2. Instead, we can use terms of grammar such as **S**, sentence, **N**, noun, **NP**, noun phrase, **VP**, verb phrase, **V**, verb, **PP**, preposition phrase, and conjunction **N**. This is a typically mathematical way to deal with large sets by naming them all with one name. All possible nouns, therefore, are **N**, whether it is a Roman emperor or a cat. What remains of the structure after the apples are picked up from the encircled tips, is shown in Figure 11.4. This graph contains information about which words are syntactically connected and which are not. Instead of words themselves we see here their grammatical functions. It is nothing but a formula, similar to formulas of mathematics as well as chemistry, while a biologist may recognize in it a certain type of a plant root, again, in a very general form, or an overturned plant, such as cactus, or an evolutionary tree of certain species.

In Figure 11.4 we can see the same general character of the *pattern* covering a large number of *configurations*. Unlike the syntactic patterns, many semantic patterns can be linked together in a large semantic network, as in Figure 11.5.
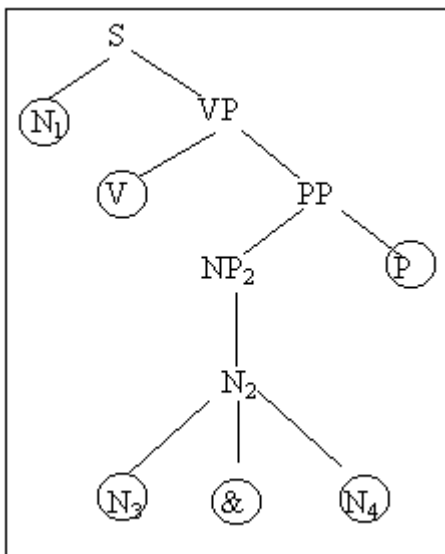
Figure 11.4. Syntactic structure

The idea of semantic network comes from the observation that whatever exists in the world, natural or artificial, consists of two sets of components. The first one comprises relatively stable independent units or terms—atoms of the world—such as Peloponessian War, Octavian Augustus, Rome, Cartage, The Third Punic War, Hannibal, Scipio Africanus, democracy, terror, emperor, war in general, insurgence, writing, and, to look around, window, photo, computer, microphone, typing, chair, sitting, staple, stapling, stapler, etc. All those objects, things, people, and actions can be used as labels for nodes of a certain graph.

The second set is binary relationships. In the English language the difference between a term and a relation is often blurred because the same word can be used as verb, noun, and adjective. War is not only a term, but also a relationship and it connects two enemies, like Rome and Cartage. End is a term, and also a relationship between an event and a point in time. Having that in mind we can read the part of a larger semantic network related to Punic Wars and shown in Figure 11.5. Even if the names Rome and Carthage do not ring the bell, the chart tells something about a deadly accident at the intersection of their historical pathways.

Semantic networks can be extended without limits. If we include the episode of spreading the salt over the ruins of Carthage, we can smoothly pass a bridge from history to chemistry.

 Simple illustrations in textbooks on semantic networks are confusion-free. Anybody who tries to visualize in this way a consistent and extensive text, however, can be easily frustrated by

the fuzziness, redundancy, and ambiguity of our language, which is, on the other hand, its greatest joy. Nothing contributes to our appreciation of plain language as much as trying to convert a piece of text into a semantic network.

Equivalent semantic networks could be built in different ways, and there is no standard one. For example, we can connect **Scipio** and **Carthage** with the arc ***destroy*** or we can do it as **Scipio**→*action*→**Destruction**→ *object* →**Carthage**. Instead of the frivolous *is a* we can use the more ponderous *is a member of the set of*.

One may ask why do we need to bend, warp, and torture our written and spoken language that is so delightfully linear. The whole problem arose from the subject of knowledge representation in both humans and computers in the domain of science called artificial intelligence where the natural language, naturally, sounds pretty artificial.
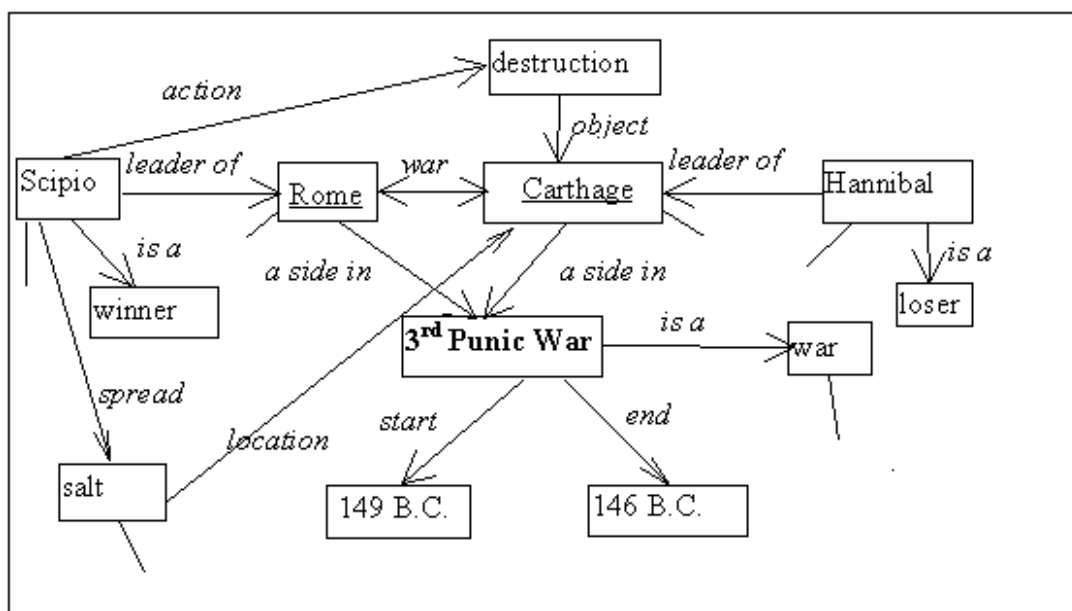

Figure 11.5. Rome and Carthage as semantic network

A semantic network built upon a text means a formal representation of a piece of knowledge. The meaning is a structure different from the syntax. Computer is good at

remembering texts but if we want it to understand the text, i.e. build the semantic structure, we need either to do it for the computer or teach it to do that on its own.

Knowledge is represented inside the computer not as a picture but rather as a graph in its matrix form. In this form knowledge can be processed by an intelligent computer.

We can, of course, use various kinds of labels for binary relations, but it would not really matter much for the structure. However we link **Scipio** and **Carthage**, **destruction** will always be lurking nearby. The semantic network, with all its fuzziness, has a certain topology, therefore, reflecting some important properties of the real world. This cohesive influence of the world on its reflection in a semantic network is very typical. The world and its semantic network are made of different stuff, but, as Spinoza said,

> The order and connection of ideas is the same as the order and connection of things (Spinoza, *Ethics*, Proposition VII of Part I).

There could be no one-to-one correspondence between words and their meaning, as Noam Chomsky illustrated with the sentence *Visiting relatives can be a nuisance*. It has two meanings, but they are in fact very close and converge on the association between relatives and nuisance, which may not be the case in a more functional family. Besides, it would be unambiguous in many other languages.

Similarly, *Revolution is a blessing* and *Revolution is a tragedy* converge in *Revolution is blessing for some and disaster for others*.

To summarize, our images of the world can be different, but they still convey, in an indirect form, some invariances of the world, *patterns* in our terminology, .

Regarding the distinction between the text and its meaning, it is appropriate to ask whether history has any meaning beyond its immediate semantics. For example, we perceive the story of the French Revolution in terms of names, places, and such categories as conflict, events, personality, institution, etc., all that as ready-to-eat apples, but what about the tree bearing the fruit? Is there another pattern space behind the narrative, similar to the patterns of syntax?

As it is always the case in humanities, there are two opposite opinions on whether history has any meaning, with a stack of intermediate views in between. One of the oldest views of history, coming from St. Augustin, sees God's will behind history. The Enlightenment saw history as a natural process driven by properties and aspirations of human nature. Some historians believed in a historical determinism driving civilizations through cycles of destruction and rebirth. Karl Marx noted the role of production of inanimate things in the social evolution—an opinion that is difficult to discount in the modern industrialized world obsessed with production and consumption.

In general, the more a body of knowledge grows, the more there is to deny. Karl Popper, like some other modern philosophers, denied any deterministic meaning of history, but noted: "*although history has no ends, we can impose these ends of ours upon it; and although history has no meaning, we can give it a meaning,*" (Popper, 1959, p. 310), which is a good example of eloquent ambiguity/ambiguous eloquence.

The thrown stone first flies up and ahead, then down and further ahead, following a specific parabolic curve. This is what we see on the surface. The task of science was to look behind the appearance and represent the event in different terms, such as mass, acceleration, velocity, and force.

While history may study a civilization at a certain stable period of its existence, describing its organization and institutions, sooner or later this synchronic, stationary description must be complemented by the diachronic one, i.e., portraying the change in time. Thus the French Revolution can be represented as a series of slides or momentary shots showing a certain structure in the process of change, geopolitics of a continent must reflect the changing borders and a nation in a series of conflicts.

The charts, graphs, and semantic networks concerning particular events do not appear to reveal much of order and regularity. If history followed strict formulas, we would be much less interested in it because we would know what to expect. The chart in Figure 11.4, however, looks different: it is exactly a formula that can generate a series of particular phrases by substitutions. Its points seem to be glued together by some invisible substance.

An important property of this chart is a certain force acting upon its elements, like the force of gravity that pulls the stone toward the ground. Thus, the noun phrase attracts the verb phrase, a noun ambushes an adjective, and a verb lures and adverb, while several conspired nouns pull in the conjunction *and*. Although in some languages, like German, the linked words could be separated by a very long chain of other words, the long-distance interaction is not typical, and connected words stay close to each other.

It looks like some mutual attraction, affinity, or repulsion exist between certain elements of a structure, but not others. This observation prepares us to a more accurate concept of generator: a structural element interacting with other elements in a selective way.

We will assemble the entire pattern picture in Chapter 16.

12. Geopolitics of Europe

Along with genealogical trees, maps are essential non-verbal illustrations of history. Up to present, history has been a series of map redrawings and it seems to be so in the future. In a more distant past, the changes followed conquest and expansion, as well as destruction and demise, while in our times they are mostly related to the ongoing national self-determination.

We can portray an essential part of geopolitical information by connecting two neighboring countries with a line symbolizing a common border. This border could be a strip of water, as between England and France or Sweden and Denmark, and all maritime nations are, in a sense, neighbors. In the second half of the twentieth century air and space made all nuclear countries watchful of each other.

Among various pattern projections, global topology has a history of its own, shaped exclusively by weapons and communications.
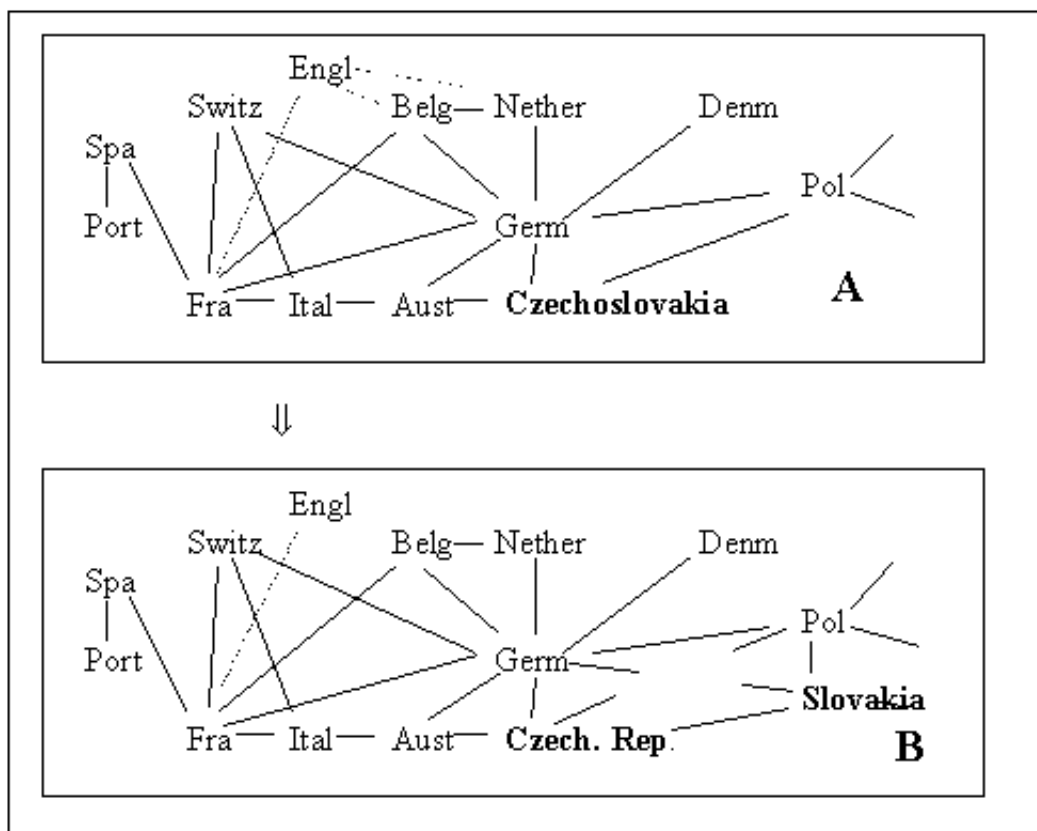
Figure 12.1. Geopolitical transformation of Europe

Graph is a topology because it defines a binary relation between every two nodes that are either connected or not at all.

The graph for the major border structure in modern Western Europe looks like Figure 12.1B. We can see at once how much information is lost in the geopolitical topology as compared with the actual map, but a lot of the topological information remains intact.

Geographically, England is not connected to anything over the land, and we cannot tell from the graph whether it is closer to Italy than to France. The Tunnel makes England a formal

neighbor of France. Britain was close enough to Russia during the Crimean War (1853-1856) when her troops fought on Russian soil.

Waterways have been preferred channels of conquest since ancient times. Vikings used both waterways and land most extensively and efficiently in their invasions because they could not only transport horses on their ships but also portage the ships between the rivers. We can find this nautical topology where everybody is connected with everybody also in a circle of friends, an economical or political alliance, and even in a living organisms where biochemical messengers produced by some cells circulate all over the bloodstream in search for their receptors.

NOTE: Maps challenged topology with the famous mathematical problem: what is the minimal number of different colors to color a map so that no two neighboring countries are painted with the same color. The answer was four, but it took over one hundred years to prove it.

The difference between the graph and the map or any other drawing is that the graph does not have metrics. i.e., distance, even though our drawing of a graph has lines of certain length. Yet even this limited symbolism makes possible to portray important historical changes. Thus, the modern geopolitical graph of Europe, Figure 12.1B, was preceded by Figure 12.1A.

Here Czechoslovakia is not yet split into Czech Republic and Slovakia. Diagrams of this kind can lead us backwards in time to the Roman Empire. Geopolitical history of Europe can be

presented as a series of changes of this graph, starting from the earliest times when borders appeared, and we can see it in educational animations.

Note that border is not human invention: many animals, such as wolves and lions, mark, maintain, and protect the border with other animals of their species.

Change of the border structure is an essential element of history, along with changes of institutions, ideas, and technology. The geopolitical history can be visualized as a succession of snapshots like Figure 12.1 where we can see addition of new generators and elimination of the old ones, as well as changing distribution of bonds and their type depending on the character of relation. The process was very active since the expansion of Roman Empire. The empire of Charlemagne broke up after his death. Soon what was to become France shrank and instead the Holy Roman Empire grew in Europe.

The geopolitical activity has been coming to a halt in the Western Europe, while there are areas of volcanism in the Eastern Europe. The end of the Soviet Empire was the major tectonic catastrophe. Internal stress is visible in Canada. The fate of the European Union is not certain.

Formally, nothing prevents us from attributing a label or even a number to an ark of a graph. Such graphs are called colored, although the property of an ark can be anything, for example, the driving distance on a road map.

On the topological version of a map we can indicate, for example, the relationship between two neighboring countries. This particular information would certainly be of little value in modern times when practically all nations are diplomatically connected. For an air strike, the border does not matter much.

The very notion of the border has changed dramatically. Considering ancient empires, we cannot speak about the borders in modern terms.

In terms of topology, the world history as we know it has been a constant transition from the changing topology of territorial animals to the metric topology of national states and, starting from the WWI, to the full (i.e., fully interconnected) graph of global politics. One of many projections of history, therefore, is, first, the rise of the metrics of a two-dimensional map and, subsequently, the devaluation of distance not only due to means of transportation and communication but also due to the *topological revolution* in relations between national states.

The space where we walk and drive is metrical. Any point of it has a certain distance from any other point. There is a dog and a cat ten feet apart. The space where we think, however, is not metrical in the same sense because we cannot measure the distance from the idea of cat to the idea of dog with a measuring tape. There is certainly a metrics: cat and dog are closer to each other than cat and dollar bill, while dollar is closer to yen than to paper napkin, all three relatives.

What is the distance between Augustus and Nero, for example? If we measure it in generations, it is four, if in years, there were 23 years between death of Augustus (27 B.C. to 14 AD) and birth of Nero (37-68 AD). Although these numbers are hardly meaningful for a historian, from all the above examples we can derive a notion of discrete metrics significantly different from the one usually associated with geometry and the measuring tape. The concept of metrics, however is much more general.

In Figure 12.2A and C we repeat part of Figure 8.3. Matrix B shows not only the connectivity of the graph but also the actual distances between the nodes, with the side of the hexagon as the unit of measurement. Matrix B, therefore, reflects some metric properties of Figure 12.2C.
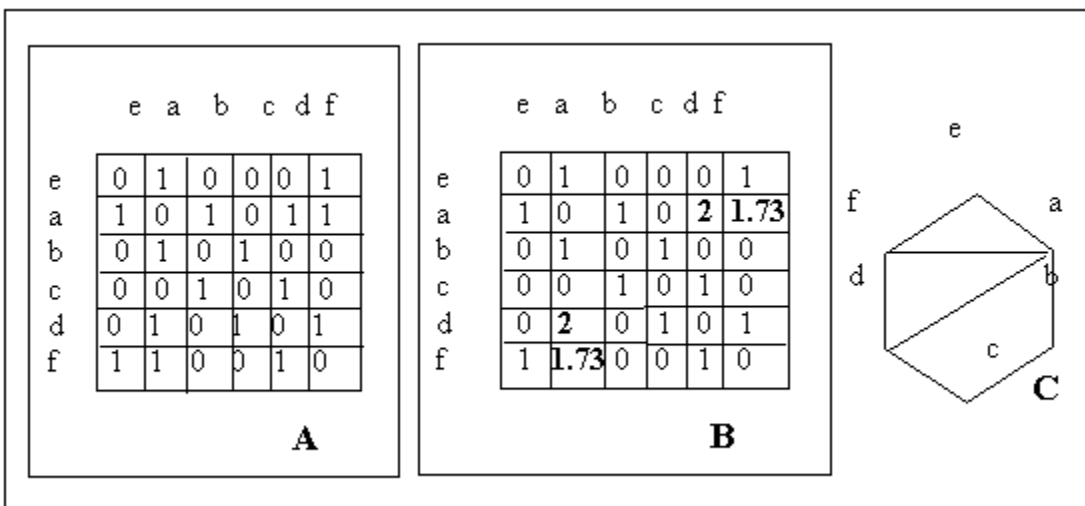
Table A

	e	a	b	c	d	f
e	0	1	0	0	0	1
a	1	0	1	0	1	1
b	0	1	0	1	0	0
c	0	0	1	0	1	0
d	0	1	0	1	0	1
f	1	1	0	0	1	0

Table B

	e	a	b	c	d	f
e	0	1	0	0	0	1
a	1	0	1	0	2	1.73
b	0	1	0	1	0	0
c	0	0	1	0	1	0
d	0	2	0	1	0	1
f	1	1.73	0	0	1	0

C

Figure 12.2. Metrics

To generalize this idea even more, we can write any symbol, or word, or even a whole story as labels of the binary relationships. One important class of values is probability of transition from one state to another or the probability of connection between two points.

We started with simple graphs and carefully proceeded toward more exotic square tables in order to demonstrate that a whole bunch of cardinal mathematical ideas developed in large branches of mathematics such as group theory and topology stem form a single general idea of a set with a binary relation defined on it. The binary relation in a form, say, of a love story between Romeo and Juliet might look very frivolous even to some mathematicians, but it is still a binary relation, and, therefore, a mathematical object.

We have taken to such length in preparing the reader to the concept of pattern in order to soften the non-scientific reader's possible prejudice. Mathematics is just as much a product of human mind as *belle lettres,* and may have as much artistic beauty. Sciences and humanities are not made of matter and anti-matter. The moat separating them is at some spots so narrow that we can easily step over it back and forth.

Any value associated with a bond produces metric patterns, whatever this value means. For example, we can attribute to each arc of the Augustus-Nero graph a number expressing the degree of their mutual attraction or hate. It is easy to prove hate: Agrippina Junior was said to murder Claudius with poisonous mushrooms, and she was in turn assassinated on orders of her son Nero, who also had all three of his wives killed and finally killed himself, but an ultimate proof of love is more difficult to get.

We can also rate the relationship between neighboring European nations on a certain scale, and no doubt, over some long historical periods the rating would be pretty low for France-Germany, France-Britain, Sweden-Denmark, and Poland-Russia.

Bond couple, therefore, can be stronger or weaker. Moreover, it can be positive or negative, and the history of Europe has been a history of not only disputes but also working alliances.

Switzerland, as it is well known, has managed to stay away from open expression of both love and hate to her neighbors for about half a millennium, which gives us a reason to call her bonds with them neutral, i.e. neither positive nor negative.

To summarize the important concept of metrics, it is any property of a bond between two structural units that can have a numerical expression of value other than 1 and 0 or *yes* and *no*.

Even if the individual bond can have only two values, 0 and 1, a certain metrics is possible for the structures. Thus, the genealogical distance from Augustus to Caligula is longer than from Augustus to Julia, while he is not related to Claudius at all. Not surprisingly, the distance of this kind is important in biology and genetics, but has little value in history.

By metrics, therefore, we shall mean a varying property of an individual bond, with the geographical distance as the closest visual analog.

As we shall see, in most cases we do not need to measure the bond values and express them in numbers to come to any conclusions. What we can often do is to compare two values and in this way tell which one is more than the other. If one bond is stronger than the other, then the weakest one will probably break down under stress.

Nevertheless, we have a good reason to expect that, in the new globalized and computerized world, the non-geometrical bond values could be somehow measured more or less accurately. For example, the higher the trade between two nations, the more positive the bond, while the more skewed the trade balance, the more probable a conflict. In Chapter 27, *History and Computers* we will discuss it in more detail.

Our very first steps on the pattern terrain seem to carry a promise that as soon as we outline a certain social, national, or geopolitical structure, for example, in terms of points and lines, and rate them along a certain scale, we will be able to look for some kind of physics that governs its possible change, similarly to the way molecules undergo chemical transformations according to the laws of nature.

Our skeletal map in Figure 12.1 conveniently ends with Italy and Austria, sparing us of the geopolitical complexity of the Balkans. Former Yugoslavia, united under Yosip Broz Tito, split after his death into independent states and plunged into bloody conflicts with Serbia trying to prevent by force its own further split.

The question that we are interested in here is the relationship between the patterns of unification and split. The map of Europe was much more patchy in the Middle Ages. The process of consolidation has been going on since then, entering now the stage of the European Community. The unification requires the reconciliation of border conflicts, quenching the aggressiveness of the nations hurt by the consequences of wars. We see in this process the

European atomism: formation of nations bound together by strong internal forces, similar to those that hold together the atoms in a molecule (although we would not venture to attribute any numbers to it).

In pattern theory a subconfiguration under certain conditions can be considered a single generator. This situation is shown in Figure 12.3, where generators **B**, **G**, and **H** form bond so strong and stable that they stay in the configuration as a new generator.
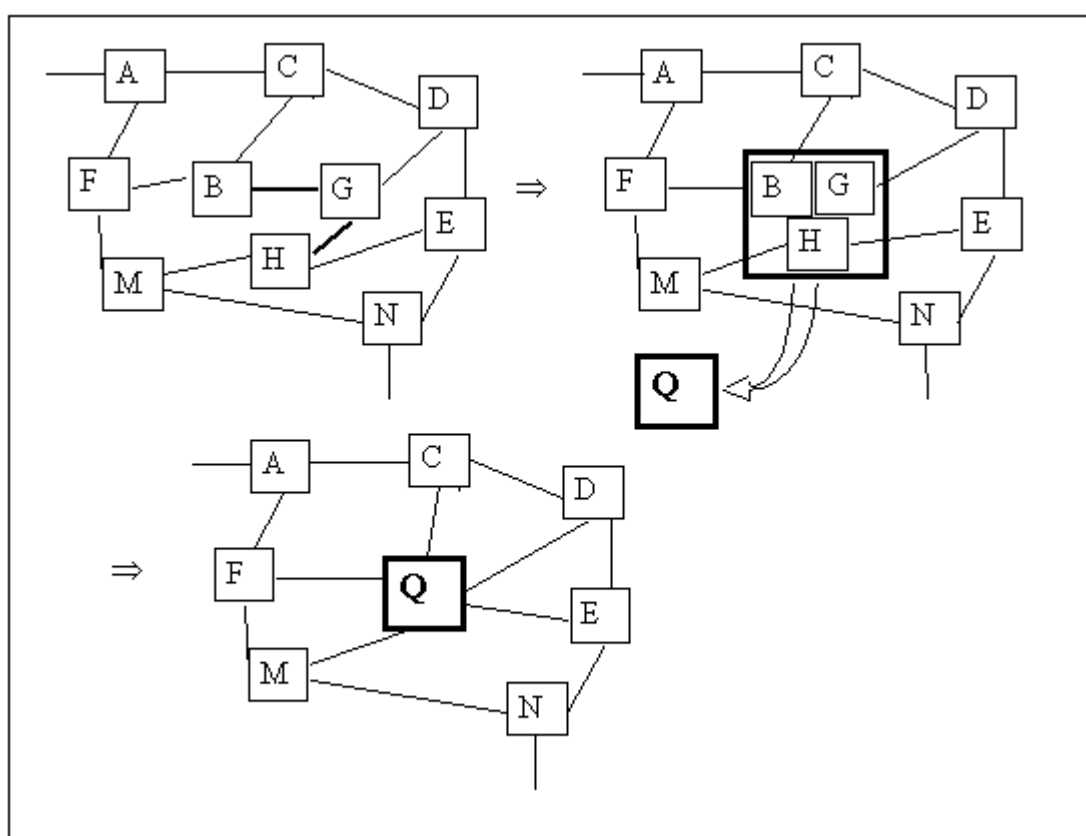

Figure 12.3. Formation of a new generator from a subconfiguration

It is exactly the internal stability achieved by European countries (nobody knows for how long) that created conditions for an attempt of unification. Following the same line of reasoning we may anticipate the separatist tendencies on the Southern border of USA if some states

become internally divided. The American Civil War fits this pattern perfectly: the Southern states based on slavery were internally unstable. Same happened with USSR: internally unstable, it not only dissolved itself through an incredible authoritarian mechanism, without any referendum, but also dissolved its system of alliances with its political satellites. The united Germany was possible only because of the internal instability of its Eastern part.

Prophesying the European Union half a century before the actual event, Crane Brinton noted,

> France has been, especially since 1189, so nearly the complete nation-state, so nearly unified in culture and habits, disunited only in the half-unreal struggle of party politics, that we are likely to regard her building-up from these medieval fragments as somehow predetermined, "natural," and therefore inevitable. It seems impossible that France could ever have been other than she is. And, at the same time, we may tell ourselves pessimistically that to go beyond the nation-state, to build something new and greater from units like France, is unnatural, artificial, and therefore impossible (Brinton, 1961, p. 51).

We are coming closer to a new alternative view of structure, which was only very briefly mentioned in Chapter 5, *Three Views of the World*, and is related to the way chemists view the world and its transformations. There is one remaining preliminary topic, however, that preoccupied scientists concerned with most general problems of change.

In the next chapter we shall continue our search for points in lines, alias, binary relations in history.

13. Two velvet revolutions

To find the points and lines lurking under the surface of a historical narrative, let us compare descriptions of two oddly sub-violent revolutions.

The Glorious Revolution in England is described in the following excerpt from an encyclopedia (Encarta, 2000).

> James II soon lost the goodwill he had inherited. He was too harsh in his suppression of a revolt by James Scott, Duke of Monmouth (an illegitimate son of Charles), in 1685; he created a standing army; and he put Roman Catholics in the government, army, and university. In 1688 his Declaration of Indulgence, allowing Dissenters and Catholics to worship freely, and the birth of a son, which set up a Roman Catholic succession, prompted James's opponents to invite William of Orange, a Protestant and stadtholder of the Netherlands and husband of the king's elder daughter, Mary, to come to safeguard Mary's inheritance. When William landed, James fled, his army having deserted to William.
>
> William was given temporary control of the government. Parliament in 1689 gave him and Mary the crown jointly, provided that they affirm the Bill of Rights listing and condemning the abuses of James. A Toleration Act gave freedom of worship to Protestant dissenters. This revolution was called the Glorious Revolution because, unlike that of 1640 to 1660, it was

bloodless and successful: Parliament was sovereign and England prosperous. It was a victory of Whig principles and Tory pragmatism.

In short, the sequence of **actions** was as follows:

James II of England

> **suppressed** the revolt of Duke of Monmouth,
>
> **created** the standing army,
>
> **put** Roman Catholics in the government, army, and university,
>
> **allowed** Dissenters and Catholics to worship freely,
>
> > and so **antagonized** his opponents**.**

His opponents

> **invited** William of Orange to come and to take the crown.
>
> William of Orange
>
> > **landed** and
> >
> > **took** the crown
>
> James II
>
> > **fled**

Our second example is the July Revolution of 1830 in France (Encarta, 2000), also praised for little violence by local standards: three days of street fighting.

The main cause of the July Revolution was the reactionary policy followed by Louis XVIII and his brother, Charles, who had become king in 1824. Two classes, the nobility and the clergy, foes of democratic progress, were shown special favor. These favors included partial payments for lands the state had confiscated during the French Revolution; readmission of the Jesuits, who had been driven out of the country during the Revolution; and clerical control of education. In

addition, Charles took severe measures against the liberty of the press. In March 1830 the Chamber of Deputies, the lower legislative house, demanded the dismissal of several of the king's ministers. In response the king dissolved the legislature. The king ordered new elections, but the results indicated that the new legislature would be even more strongly opposed to the policies of Charles than its predecessor had been.

On July 26, a few days before the new legislature was to meet, the minister of domestic affairs issued ordinances completely suspending the liberty of the press and declaring the new elections null and void. The people revolted, and rebels took possession of the municipal government in the city hall. By July 29, after three days of fighting, the entire city was in the hands of the workers and the middle class. Charles withdrew his minister's ordinances, but it was too late. Charles was forced to abdicate, and he fled to England. The workers advocated a republican form of government, but the liberals, supported by statesman Marquis de Lafayette, favored a limited monarchy under Louis Philippe, duc d'Orléans. On August 9, Louis Philippe was elected king.

In short,

Charles II of France

suppressed the liberty of the press,

nullified elections,

readmitted Jesuits,

reinstalled clerical control over education,

repaid the confiscated property of nobility and clergy,

and so **antagonized** his opponents.

His opponents

revolted

Charles II

fled

His opponents

offered the crown to Louis Philippe

The two descriptions reminiscent of chemical *mechanism* , i.e., sequence of elementary steps, point to similarities between the two revolutions, which was duly noticed by historians.

Next we shall try to express the similarity formally. For that purpose, we rename the terms, using the following more abstract terms in the descriptions.

Event: REVOLUTION.

Characters :

LEADER   A (James II, Charles II)

OPPONENTS (workers, middle class, and unspecified people)

LEADER B (William of Orange, Louis Philippe)

Actions :

ANTAGONIZE OPPONENTS

REVOLT

FLEE

OFFER CROWN

TAKE CROWN

The action ANTAGONIZE OPPONENTS includes a series of actions such as

SUPPRESS (revolt),

SUPPORT (unpopular religious group),

NULLIFY (elections), etc.

Finally, there are OBJECTS of action:

DM (Duke of Monmouth)

J (Jesuits), etc.

This gives us a set of terms belonging to a certain formal language suitable for describing *similar* historic events separated in time and space.

The two narratives look similar because there is a hidden structure of the formal language behind them. It looks very similar to the tree-like syntactic structure in Figure 11.4. It generates fragments of historical descriptions by substituting particular words for general terms.

Stimulated by the study of formal languages by Noam Chomsky (1957), the task of generating phrases, statements, and texts out of modular elements was widely explored in linguistics and artificial intelligence.

There are various types of formal languages. According to the principle of the *final state language*, the generation of a text is regarded as a sequence of steps between the beginning and end. After each step there is a selection of blocks to be chosen and so-called rules of rewriting. The term "rewriting" means a substitution of a less general block, for example, DOG for a more general one, for example, NOUN.

A formal language consists of:

1. Non-terminal symbols or syntactic categories: SENTENCE, NOUN PHRASE, NOUN, ADJECTIVE, etc. They are somewhat similar to mathematical variables, for example *a, X*, etc.

2. Terminal symbols—the apples of Figure 11.2—which are particular words from the dictionary of the language. Thus, *a* can be 2, 3, or 45.

3. Rules of rewriting, otherwise called production, from more general to more concrete structures.

For example, SENTENCE (S) → NOUN PHRASE (NP), VERB PHRASE (VP) means that we can substitute a pair of any NP and VP for any S, like we can substitute numbers for letters in expressions a = b + c or X=Y·Z.

If NP → the NOUN , then it is possible to rewrite: NOUN → cat

Grammar, therefore, is regarded as a kind of a machine producing phrases according to some rules of connection.

Cookie recipes are also controlled by a grammar that consists of large standard blocks: mixing water, flour, and sweetener, adding spices, shortening, kneading, rolling, and baking. Various recipes can be generating by rewriting the general pattern, specifying sweetener as sugar, honey, molasses, or saccharine, etc., adding optional filling, which also can be rewritten as jam, currants, nuts, etc., or specifying the shape of the cookie-cutter. The concept of generative grammar is very general.

This imaginary machine—which is a non-numerical mathematical object known as algorithm—can generate grammatically correct stories, whether real or totally unreal. As far as history is concerned, such machine can not only write various "what if" scenarios but also expand the counterfactual history to accounts of completely fictional events. In the same way, by combining standard blocks of narrative, one can write novels, scripts, and fairy tales, and the whole process can—and has been—computerized in games for children.

It is appropriate to point here to an analogy with the development of a multi-cellular human organism from a few identical cells of an early fetus. There must be a universal grammar in the developmental mechanics of cells to guide the subsequent expression of the genetic code into a unique organism. Similarly, a writer sometimes starts with a few words, outline, or a

general idea and then literally rewrites it, i.e., unfolds a small sketch into a novel through a sequence of concretizations, expansions and changes.

The combinatorial nature of a narrative was first explored in the 1930's by Vladimir Propp (1895-1970). He described the structure of folk tales in terms of standard blocks and their combinations, well ahead of the developments in artificial intelligence (Propp, 1968).

A design for a possible machine that could specialize in writing history of velvet revolutions is shown in Figure 13.1.

We start with the initial state **1** and generate the first block containing the name of a historical person, which brings us to the state **2**. Next, we have a choice. We can go straight to the state **3** or go into the loop to pick up another block describing the action: harshly, cautiously, etc.

The same grammar can generate an utterly fictional revolution resulting in the displacement of an unfortunate king Aspirinos by his lucky rival king Ibuprofis.

We could also compound stories along the principles of Vladimir Propp. The narrative for both revolutions would have the following formula:

1. LEADER **A**

    2. HIS DESTABILIZING ACTION

    3. ALIENATION OF OPPONENTS

    4. ANXIETY OF OPPONENTS
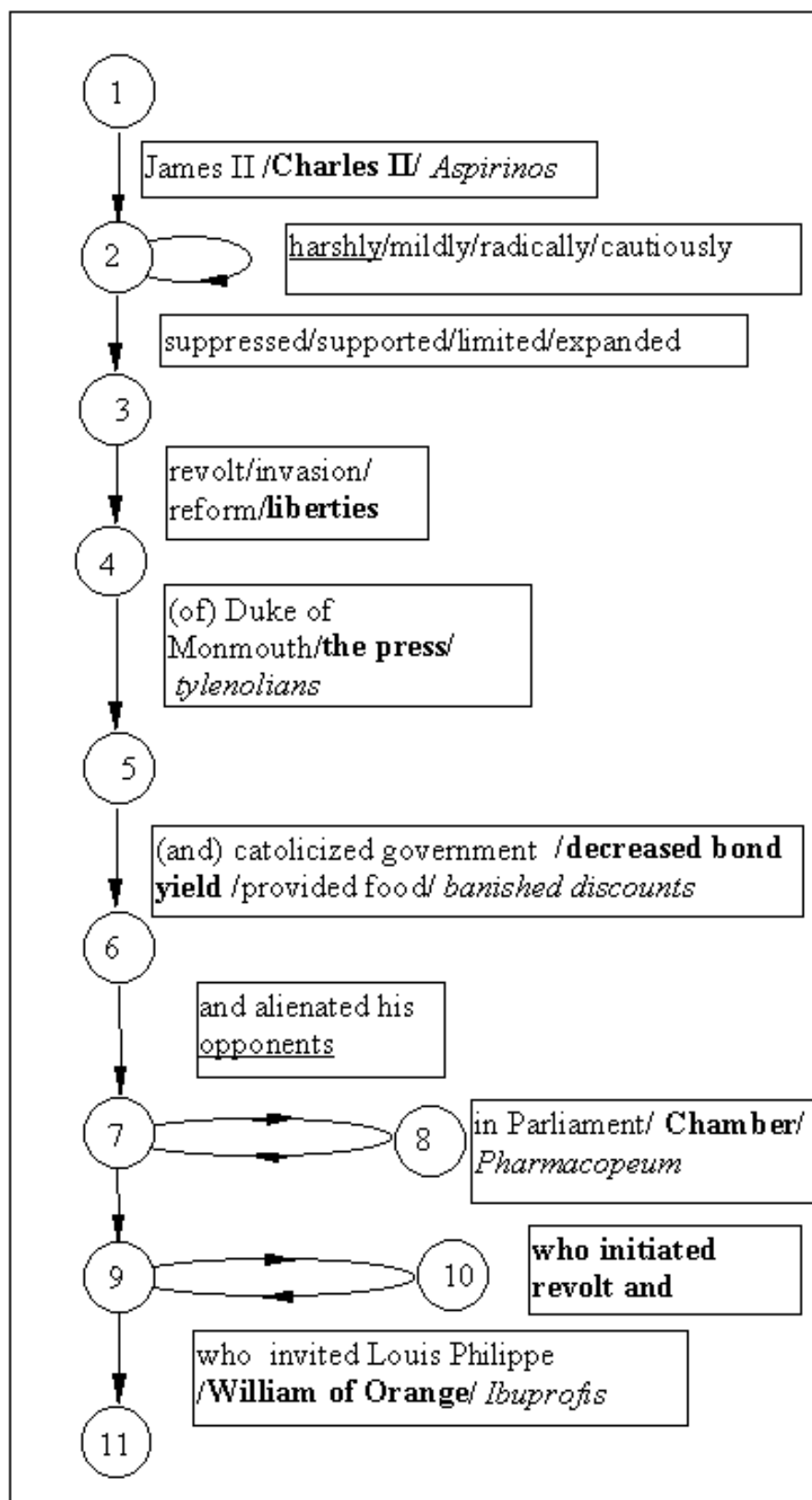
5. OPPONENTS OVERTHROW LEADER **A**

Figure 13.1. A grammar for a velvet revolution

AND INVITE LEADER **B**

Versions of 5:

5A. OPPONENTS REVOLT

LEADER **A** FLEES

OPPONENTS INVITE LEADER **B**

5B. OPPONENTS INVITE LEADER **B**

LEADER A FLEES

Here is how a narrative could be generated by *simultaneous* unfolding of the hidden structure, according to another type of formal language with the so-called context free grammar. This is, probably, how some novels and Hollywood scripts are written:

A MEANS OF TRANSPORTATION (MT) IS BOOBY-TRAPPED, where MT is AIRPLANE, TRAIN, BUS, CAR, SKATING BOARD, SNEAKER... and so on until the HAPPY END.

In our example the steps of unfolding could be:

1. James lost the crown to William.

2. James alienated his opponents and lost the crown to William

3. Catholic James alienated his Protestant opponents and lost the crown to Protestant William.

4. Catholic James alienated his Protestant opponents by creating a standing army, putting Catholics in the government, army, and university, and allowing Dissenters and Catholics to worship freely. He lost his crown to Protestant William who was invited by his opponents, landed, and took the crown.

In humanities, the combinatorial paradigm is known as structuralism (Ferdinand de Saussure, Levi-Strausse, and a large cohort of followers).

The achievement of structuralism was not just the analysis of the combinatorial nature of human social and cultural life. Another equally fundamental and complementary—but less remembered—idea was expressed by Claude Levi-Strausse, who noted that a great variety of actual attitudes of people toward each other were covered by a limited number of kinship relations.

> A few further remarks here may underline the striking analogy between the development of this problem and certain stages in the evolution of linguistic theory. The variety of possible attitudes in the area of interpersonal relationships is almost unlimited; the same holds true for the variety of sounds which can be articulated by the vocal apparatus—and which are actually produced during the first months of human life. Each language, however retains only a very small number among all the possible sounds, and in this respect linguistics raises two questions: Why are certain sounds selected? What relationships exist between one or several of the sounds chosen and all the others? Our sketch of the historical development of the avuncular [uncle-nephew relation] problem is at precisely the same stage. Like language, the social group has a great wealth of psycho-physiological material at its disposal. Like language too, it retains only certain elements, at least some of which remain the same throughout the most varied cultures and are combined into structures which are always diversified. Thus we may wonder about the reason for this choice and the laws of combination (Lévi-Strauss, 1963).

The central idea here is the concept of the structure that limits the possible combinatorial explosion of human imagination and variability, so that only certain structural types survive. The world *selected,* however, opens a passage into a completely different world, which we will visit in Chapter 18, *Conflict*.

As a preliminary remark, there must be some non-structural criterion, value or parameter which is extremal—either minimal or maximal—for the selected structures. This simple but

powerful idea underlies the development of general sociology. When the cultural tide turned against structuralism, it was trampled by the new wave of post-structuralism. Ideas, however, do not die.

A champion fisherman is selected by the highest weight of the caught fish, and the runner is selected by the shortest time of the run. Miss America is selected ... well, let's skip it. How is a social or cultural structure selected?

Neither of the types of structural analysis that we described above provided a sufficiently convincing solution of the problem of selection. We will return to this later.

Figure 13.2. Struggle for power
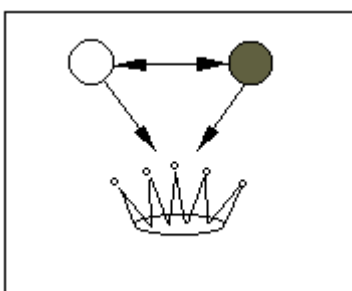
Here we would like to add an example of a somewhat different version of structural approach. We regard the revolutions as a conflict over a crown symbolizing power—a situation of countless occurrences in history, not necessarily in a violent form (Figure 13.2). The sides of the conflict are involved in a tug of war with the outcome depending on some kind of force exerted by the sides.

In Figure 13.3 we portray the two revolutions in both their similarity and distinction, as well as dynamics. In both revolutions we have a transfer of a bond between a person A or B and the position of leadership L. The diagram shows not only the initial and final states of the transition but also the brief and full of uncertainty transition state between them. In the Glorious Revolution there is a moment when both contenders formally are linked to power, while in the July Revolution the flight of the King, without an attempt to take back the crown, makes the

leadership position vacant for a short time. An organic chemist would recognize in them two basic mechanisms of chemical substitution.

The basic sequence of events is rarely disputed by historians, especially, if it was chronicled by contemporaries. History happens in a certain undeniable way, although we may differ on some points. Historians can fiercely disagree, however, on the explanations why it did not happen otherwise, and they rarely have a common ground for a dispute.

There is a notable difference between formal linguistics and classical structuralism, on the one hand, and the transition state analysis, on the other hand. With the latter approach, we can ask the question that makes little sense in the classical framework: why was this particular sequence of events selected among other counterfactual scenarios?
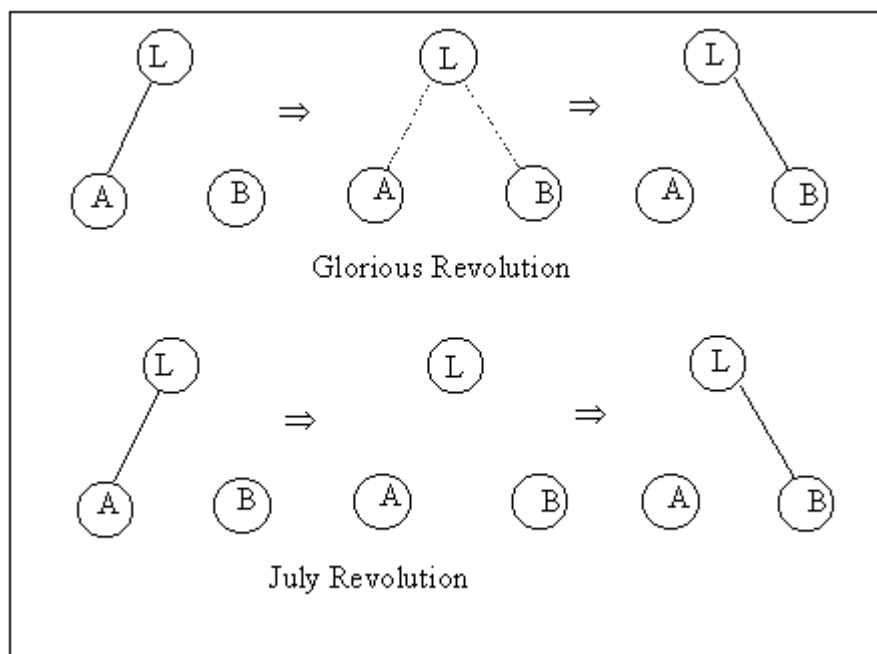

Figure 13.3. Two mechanisms of velvet revolutions

For example, from no semantic network can we derive any clue regarding whether Mary and John would buy a house or whether USA and Russia would sign a Missile Defense Treaty. Moreover, looking back toward the past, we cannot even ask why Mary and John did not rent a house instead of buying it. All we can say is that they could not buy the house they had already bought, or to sell somebody else's house. In the language-generating grammars, the basis for choosing the next word is not any real Mary or Russia, but just the statistics of the language, in other words, some artificial reality, that neither God, nor hidden laws of history, nor just pure chance, but we alone create.
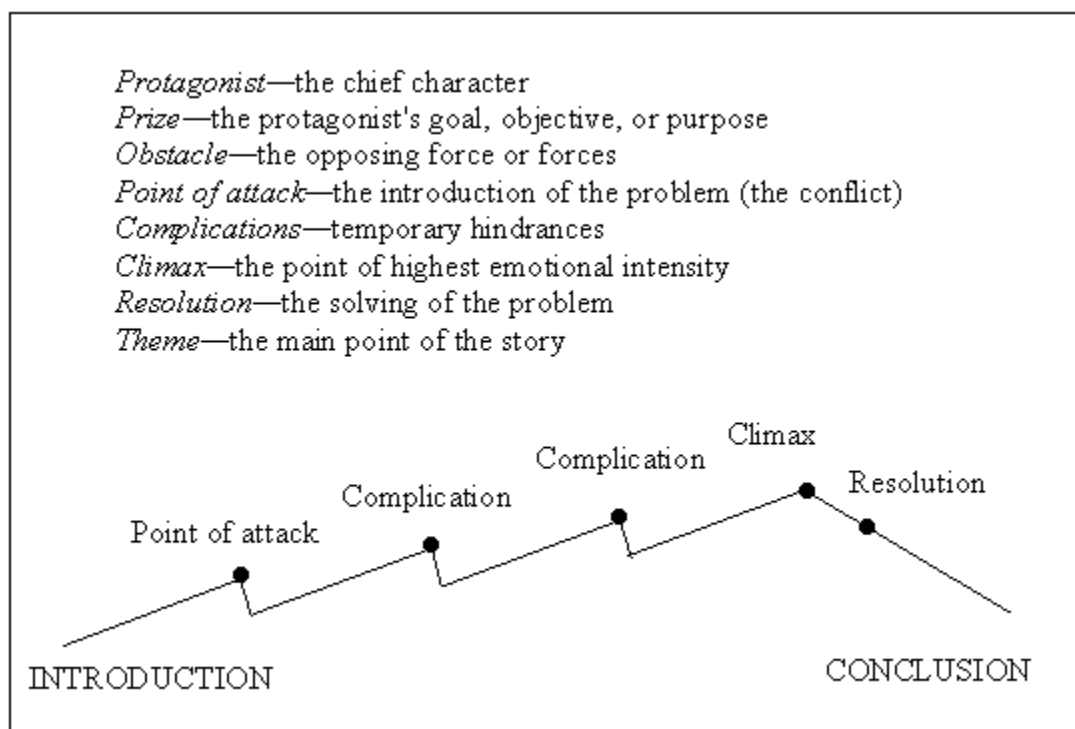

Figure 13.4. Conventional plot structure

The grammars described above are called formal because the texts they generate cannot be subjected to tests of realism, feasibility, and truth. In contrast, natural sciences either describe

real objects or design objects that can be built, or issue statements that could be proved as true or false.

We would like to illustrate an alternative approach, which invokes the aspect of force and energy, with a diagram in Figure 13.4 taken from anthology *Structure and Meaning: an Introduction to Literature* (Dubé, 1983, p.6).
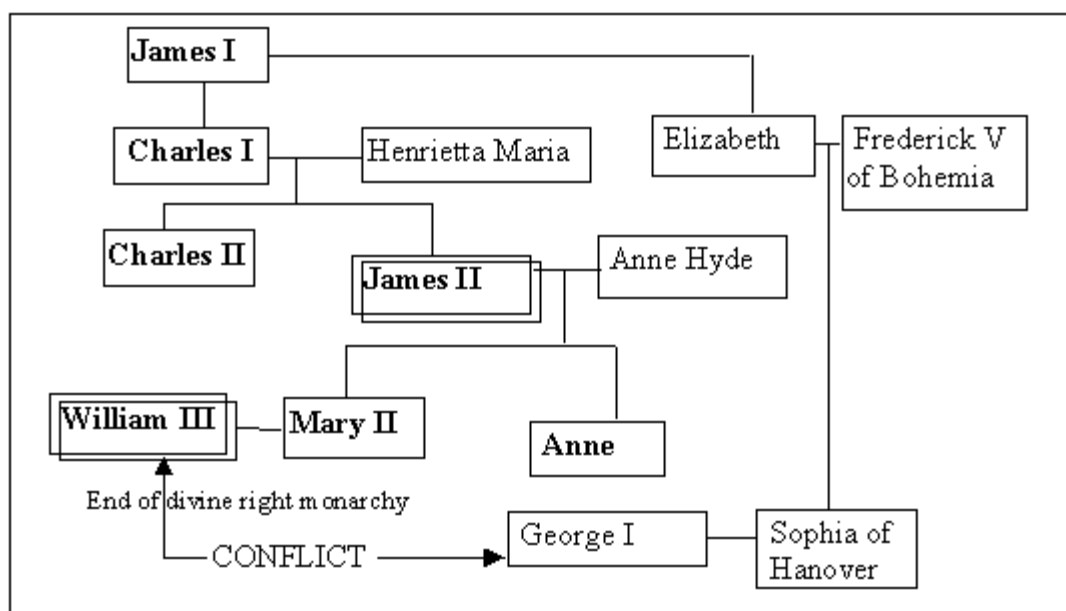

Figure 13.5. Genealogical background of the Glorious revolution

The chart could be regarded as another instance of unfolding the basic structure through rewriting, as well as a seed of a Hollywood script. A new dimension appears on this chart, however: the tension that builds up to the climax and then subsides in the resolution. This *fuzzy* parameter of tension is not structural and we can *suspect* that in *almost* all historical events the structure is characterized by *some semi*-quantitative value that determines, *to some extent*, the direction of change. We tried to be very cautious in the previous sentence. If we were not, it would be just a statement of physics with energy as the parameter.

Obviously, not only novels run between suspense and boredom. Real events, as witnessed by contemporary observers, also have a similar non-structural dimension of suspense. The anti-Taliban war in Afghanistan was the latest example.

Figure 13.5 gives us yet another projection of the Glorious Revolution: its genealogical background. The cycle here is closed by the link of conflict.

Not surprisingly, it was a family conflict—still felt in Northern Ireland.

In Chapter 18, *Conflict*, we shall look for the pattern roots of conflicts.

Our current objective is to cautiously outline some topics of pattern theory without formalizing them. We want to show that some important structural ideas have been gradually developing in humanities.

Next, since we have drawn a parallel between history and storytelling, it may be enlightening to listen to a great storyteller's view of history. It has something to do with chemistry.

14. Fermentation in wine barrel and society

Figure 14.1A presents a chemical transformation in the dot-and-line style. It is fermentation of fruit sugar (glucose) into alcohol and carbon dioxide in the presence of yeast, which is commonly portrayed as in Figure 14.1B. The fermenting sugar splits into fragments like Austria-Hungary after the World War I, British Empire after WWII, and USSR and Yugoslavia after the Cold War. Fermentation and breakdown are common metaphors of historians.

Figure 14.1A emphasizes the metaphorical aspect of the disintegration: the whole splits into fragments like a glass dropped on concrete floor. As far as fermentation is concerned, we can translate this process into a series of changes in the chemical structure. The transformation is always the same whether it takes place in wine cellars of Bordeaux or California.

The chemical equation could make a wrong impression that the atoms suddenly rearrange themselves in a new way. In fact, between the initial and final states lies a multitude of intermediate steps which can depict the process in its dynamics as movie frames do. The chemists call this sequence of stages *mechanism* (see Chapter 1) and it has a close analogy in history. The decline and fall of Roman Empire, described by Edward Gibbon (1946) in his monumental book *The Decline and Fall of the Roman Empire*, is also a sequence of steps in the mechanism of the process.

Note that the yeast *formally* does not take part in the change: it remains the same after the transformation, is not consumed, and even multiplies. Sulfur dioxide or strong alcohol are used to kill the yeast cells and stop fermentation.

Yeast makes the process possible due to its *catalytic* function. Biochemical catalysts are called enzymes. The far-reaching parallel is on hand: the ideas of the *philosophes* that catalyzed the French Revolution. Scores of people had lost their heads, but the books of Henri Rousseau did not lose a word.

Leo Tolstoy was not a professional historian. He had a very critical frame of mind and was iconoclastic on almost everything, including Shakespeare. He went as far as to suggest surrendering Russia to the Japanese when the Russian-Japanese war began in 1904. A person of his caliber could be an idol on the American campuses of the 60's and a leading dissident in Russia of the 70's.

Tolstoy was born in 1828, long enough after the French Revolution and Napoleonic wars. He had witnessed profound historical changes in Russia and her entrance into the new age, which soon would be interrupted by the Russian Revolution. He died in 1910.

Let us see how he described the French Revolution.

In 1789 a ferment arises in Paris; it grows, spreads, and it is expressed by a movement of peoples from west to east. Several times it moves eastward and collides with a countermovement from the east westward. In 1812 it reaches its extreme limit, Moscow, and then, with remarkable symmetry, a countermovement occurs from east to west, attracting to it, as the first movement had done, the nations of middle Europe. The countermovement reaches the starting point of the first movement in the west—Paris—and subsides.

During that twenty-year period an immense number of fields were left untilled, houses were burned, trade changed its direction, millions of men migrated, were impoverished, or were enriched, and millions of Christian men professing the law of love of their fellows slew each other.

As a possible response to the questions how that could happen, Tolstoy offers a parody of a typical historian's approach.

Louis XIV was a very proud and self-confident man; he had such and such mistresses and such and such ministers and he ruled France badly. His descendants were weak men and they too ruled France badly. And they had such and such favorites and such and such mistresses. Moreover, certain men wrote some books at that time. At the end of the eighteenth century there were a couple of dozen men in Paris who began to talk about all men being free and equal. This caused people all over France to begin to slash at and drown one another. They killed the king and many other people.

And so on, up to the demise of Napoleon.

Many other historical events can be described in a metaphoric way, for example, the events of the American Civil War, described by Margaret Mitchell in *Gone with the Wind* in very similar colors: "The South had been tilted as by a giant malicious hand, and those who had once ruled were now more helpless than their former slaves had ever been."

Tolstoy ridicules historians because, he says, they answer questions nobody has asked. The right question should be: what is the power that moves people?

Tolstoy sees the power not in the particular individuals and ideas. He is not satisfied with the view that the circumstances produce a historic character who exerts power to cause events. He believes that the fact that Napoleon was produced by the Revolution contradicts the fact that he suppressed it.

In the language of vector algebra Tolstoy is looking for "component forces equal to the composite or resultant force," so that "the sum of the components must equal the resultant." He refuses to see how ideas, for example, *Le Contrat Social* by Rousseau, fit in the causal nexus with the resulting drowning of Frenchmen by each other.

Tolstoy understands historical process as a continuum made up of infinitely small actions and events, with no beginning.

Only by taking infinitesimally small units of observation (the differential of history, that is, the individual tendencies of men) and attaining to the art of integrating them (that is, finding the sum of these infinitesimals) can we hope to arrive at the laws of history.

Tolstoy further makes a remarkable observation, compare with Chapter 1:

Our false conception that an event is caused by a command which precedes it is due to the fact that when the event has taken place and out of thousands of others those few commands which were consistent with that event have been executed, we forget about the others that were not executed because they could not be.

He comes to the conclusion that the conception of a cause is inapplicable to the phenomena we are examining. "Wars and revolutions occur just because it is inconceivable otherwise." History, therefore, runs according to some laws of nature.

What kind of laws could they be? He asks.

It looks like Tolstoy had something in mind, which could, probably be expressed in modern language. It becomes clearer if we look at the major dilemma of history in his interpretation: the problem of free will and necessity. If everybody were free, "history would be a series of disconnected incidents." But "if there be a single law governing the action of men, free will cannot exist, for then man's will is subject to that law."

A philosopher would object that the opposite of freedom is not necessity but constraint. But a modern scientist can understand Tolstoy by just recalling what the opposite of necessity is. Jaques Monod (1971), following Democritus, saw it as chance. What Tolstoy meant by freedom was chance, as his other remark illustrates.

> Whatever presentation of the activity of many men or of an individual we may consider, we always regard it as the result partly of man's free will and partly of the law of inevitability.

In modern language, Tolstoy refers to ordered chaos, about a century ahead of time. He mentions the laws of statistics describing the number of births or crimes, to leave no doubt that he means probability. His position is neither deterministic nor indeterministic: it comprises both chance and necessity. No wonder, because human history is a form of life.

Let us take another look at Tolstoy's portrayal of the Revolution: "In 1789 a ferment arises in Paris; it grows, spreads, and it is expressed by a movement of peoples from west to east."
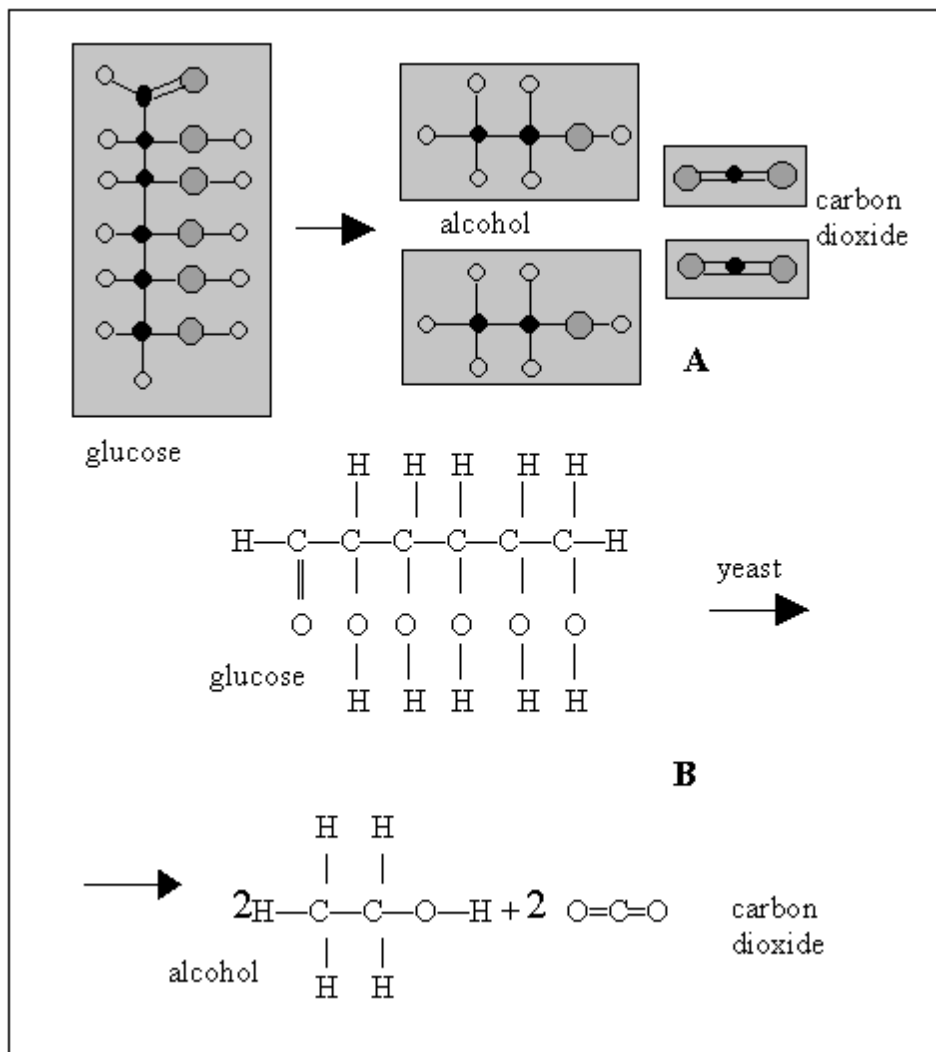
Figure 14.1. Fermentation

The naked invisible man in H.G. Wells' novel was seen as a fuzzy shape when his skin was covered with dust or rain droplets. Tolstoy in his essay about history obliquely showed us a dim figure of an invisible force moving the nations throughout history just by the way it pushes everybody around. The later developments of science have been filling the nebulous shape if not with live flesh then at least with some bones.

Tolstoy's metaphor of the French Revolution and its imperial consequences is fermentation, a state of agitation and unrest in a barrel of grape juice, resulting in a dramatic change. Breakup is a pattern of events common for history, when a voluntary, enforced, or historically developed complex of geopolitical and ethnic entities dissolves itself into its constituents.

There are some bonds between the entities at one moment, and they are broken in the next moment. This pattern, however, is trivial and it offers no insight. For a chemist, however, the process of breaking up a bond and establishing a new one is not trivial. It took about a century to understand how and why it happens. For modern natural sciences it is part of a more general problem that sounds very philosophical: why and how any change happens. It occupied the minds of philosophers from Heraclitus to Hegel to Sartre.

The condition for considering the problem of a historical change as a natural process subject to the basic laws of nature is to see it as a change of a configuration formed by certain atom-like parts and bonds between some of them. Some bonds are getting weaker, and some new ones are getting stronger, and this is how it all goes.

Fiction, history, and chemistry—what a terrible artificial mixture! One might say.

Here is the last quotation:

Imagine someone who is a compulsive borrower and goes from friend to friend asking for money. The shorter the time for which a friend can lend him money, the larger the loan he seeks. Borrow and return, borrow and return—over and over again with unflagging intensity he takes in money only to give it back in short order. Like stock prices on a wild, roller-coaster day on Wall Street, the amount of money the compulsive borrower possesses at any given moment goes through extreme fluctuations, but when all is said and done, an accounting of his finances shows that he is no better off than when he began.

The conclusion of the quotation is hard to expect if you do not know the source:

Heisenberg's uncertainty principle asserts that a similar frantic shifting back and forth of energy and momentum is occurring perpetually in the universe on microscopic distance and time intervals (Greene, 1999, p. 119).

The fusion of sciences and humanities is in the air.

15. The invisible walls of events

We have already seen (Chapter 4, *Alternatives and altercations*) that some historians are inclined to replay history in their minds and see where else it could go. Two more examples follow.

> Had Russia and Germany not been submitted to the process of disintegration and transformed into highly plastic societies, Lenin would have died as an obscure commentator on Marx, and Hitler as an obscure painter (Timasheff, 1965).

Compare that with the view of Niall Ferguson:

> Adolf Hitler could have eked out his life as a mediocre postcard painter and a fulfilled old soldier in a German-dominated Central Europe about which he could have found little to complain. And Lenin could have carried on his splenetic scribbling in Zurich, forever waiting for capitalism to collapse—and forever disappointed (Ferguson, 1999, p. 460) .

Works of historians, as well as fiction and our everyday life are full of such "would have." As we believe, this mind game is not at all an extravagance. It is an evidence of the combinatorial nature of our knowledge.

Why then were Russia and Germany disintegrating? Or, in more general terms, why was Europe in the twentieth century involved in a process of a dramatic change, with Germany and Russia going through catastrophic internal transformations while England and France were preserving their core but losing their colonial possessions? Was there any alternative to that?

For a scientist, a question about the reason why a certain process takes place can be split into three parts:

1. Why is the process possible at all, taking to account that so many imaginary processes are not? This question should be addressed to generalized *thermodynamics*.

2. Why is it faster (or slower) than another known and apparently similar process? This question is better to address to generalized *kinetics*, which is based on thermodynamics with some additional assumptions.

3. Why is it happening at this particular time and place and not earlier or later?

Unfortunately, there is nothing in physical sciences to address this question because they are devoid of the dimension of history. Physical sciences consider repetitive processes while history is the realm of the unique: Napoleons are not born twice.

Physical scientists do not pay much attention to the historical aspect of the process, i.e. its particular position on the universal timeline. A physicist could not seriously say that the stone fell to the ground *because* Galileo dropped it from the top of the Tower of Pisa. A chemist could not say that the paper burns *because* Lavoisier ignited it in a closed vessel. The physicists and chemists disregard historical particularities because the stones always fall to the ground and they would do so

whether they are thrown into Grand Canyon or from Eiffel Tower. All organic matter burns, whoever strikes the fire. .

A historian of science would say that we know about free fall and oxygen *because* of Galileo and Lavoisier. They belong to the history of science but not to the scientific explanation itself. In our discourse on history we must always be aware of the place, time, and the acting individual.

Evolutionary sciences, like astrophysics, geology, origin of life and species, history, and biography as study of individual life, have not yet consolidated into a general abstract theory because of the enormous complexity of the material and difficulty of its representation.

Any physical law, like that of universal gravitation, is a powerful statement. In social sciences, however, saying that nations have always been engaged in wars is of no value. Historians study a particular war by tracing the sequence of events and establishing causal links wherever possible. There are also historians that analyze the pattern of war or revolution by discovering common properties of a set of such events.

What we want to do is to look from a certain distance at the similarities between war and chemical process rather than at their obvious worlds-apart differences. We regard both as natural processes of transition from initial state to final state and link war and fire by more than just a metaphor.

The basic physical concept related to change is energy.

Energy is a primary concept. It cannot be defined in terms of other primary concepts. Energy is what changes during any process, from evolution of stars to understanding a mathematical equation to following the plot of a novel. A boulder and a pebble released from the Tower of Pisa

fall down because the force of gravity pulls them down. They have less energy at the foot of the tower than at the top and energy is needed to haul them back to the top.

Can we attribute energy to society in any serious way even though we cannot measure it?

As soon as we distinguish between positive and negative bonds, energy comes to the podium because the difference between attraction and repulsion amounts to the sign of energy. We can simply say that energy is what it takes to break bonds between relatives, friends, and allies, or to maintain order in a dysfunctional family, hold together the Tito's Yugoslavia, maintain productivity in a troubled company, keep peace in a region with ethnic tensions, unite the Congress split over an issue, and command the NATO alliance built of nations always disagreeing on something.

This tells very little about the nature of energy, but we do not need more depth at this point. All we need to know is that energy of a system can increase or decrease.

Not only there are definitely more or less "tense" and "frustrated" societies and smaller groups, but there are more or less "tense" theories, statements, texts, and even the whole fields of knowledge, in short, societies of ideas. Moreover, there are more or less "tense" pieces of art, whole artistic works, and even whole periods in a national culture, more or less contradicting or conforming to the current canons and to internal principles.

We can see that the tense society or area of science is usually unstable and undergoes evolution. Art loses its revolutionary fervor either because of the loss of novelty or because of transformed rules. We need, therefore, to acquire some means of measuring the "tension" at least in a non-quantitative way. It simply means that, looking at any two configurations, we need to be able to say which one is tenser or whether they are equally tense. This is how we can approach the problem of evolution of complex patterns.

A possible way to say which configuration has a higher energy is to compare the contribution of positive and negative bonds: each negative bond increases energy, while a positive bond makes the configuration more stable.
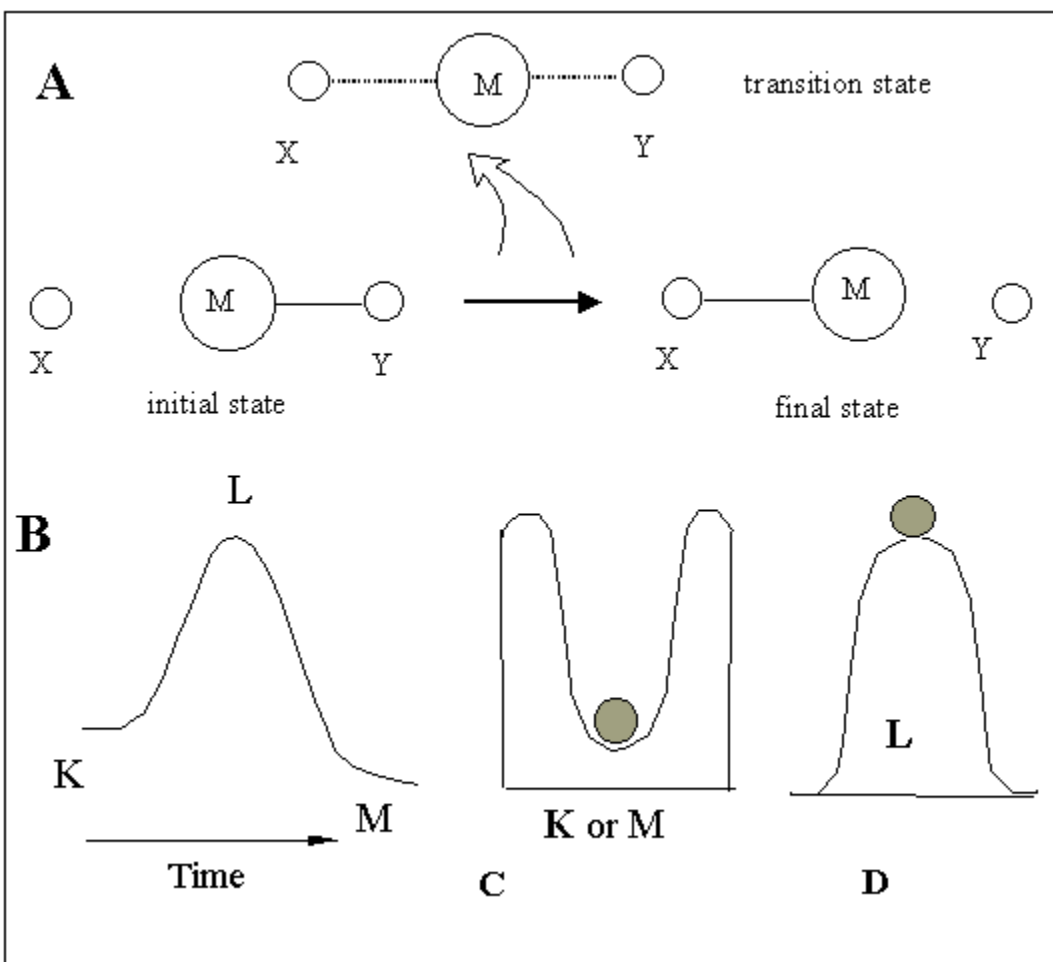

Figure 15.1. Elementary change and energy barrier

Let us look at a very elementary act of change, Figure 15.1. We start with situation **A**, where generator **M** is bonded to **Y** but not to **X**. As result of a transformation, it becomes bonded to **X** and the link between **M** and **Y** disappears.

Let us forget at this point about the meaning behind the lines, no matter whether it is a breakup of a bond between Louis XVI and his countrymen or a bond between two carbon atoms in

glucose. We are looking at an abstract mental object visualized in Figure 15.1 , which, if you wish, is a metaphor for both. In fact, it is a pattern of an elementary change.

When pattern theory relaxes the rigidity of the bond couple from yes-or-no to maybe, it means variance, and variance can be measured by probability.

If a bond couple between generators is improbable, i.e., its probability is less than 0.5, it means that it will take some work to keep the couple together. If it is probable, than it will take some work to separate the couple. Therefore, probability 0.5 separates connected and disconnected states, but when you deal with probabilities, everything is *possible*.

Referring to probabilities gives an answer to question 3, but it is a weak answer, more like a subterfuge. It is similar to answering the question why Mr. Smith got into accident with "because there was a non-zero probability of it." The causal approach would describe the sequence of events leading to the accident, without referring to other accidents. A more rigorous reductionist account would trace the accident to an increased probability of a poor vision and further to the high blood pressure and changes in Mr. Smith's retina, and even deeper: to Mr. Smith's genetic makeup.

The problem is what changes the probability of events. In our case, it is what increases the probability of a change.

When somebody breaks a twig, we explain its destruction by an intervention which is external to the twig. The idea of God punishing some nations and rewarding others is, in this sense, a scientific explanation, or at least a valid hypothesis. Yet in the case of fermenting grape juice—with all due respect for the god Dionysus whom the Greeks assigned to control it—we rely more on yeast than on any deity.

The question is, therefore: how anything can happen on its own?

Chemistry does not care much about history, although their paths sometimes cross dramatically. Antoine Laurent Lavoisier (1743-1794) was the founder of modern chemistry. He was the first to establish the composition of water and he baptized its elements hydrogen and oxygen. He was the first to explain what happens when something burns in the air. He introduced the fundamental concept of chemical element, made chemistry a quantitative science, and actually formulated the law of conservation of matter. In chemistry he was of the stature equivalent to that of Copernicus and Darwin. When he was guillotined at the peak of the revolutionary terror in France, his head fell into the basket certainly not on its own and not *because* of the gravity. On this gruesome example we can see the difference between the physical and historical explanations. On the contrary, the Revolution was not brought to France on the bayonets of invaders. It was an internal transformation of the system: the French Revolution happened *on its own* and it increased the probability of the violent death of Lavoisier.

Chemistry borrows the answer to the question how anything happens in its own from physics. In short, the logic is as follows. If there is a system that can be in several possible states, all its states can be rated by their stability. The unstable state may undergo a change immediately, while a more stable state has a particular reason to be stable: it needs a push to become unstable. The stable states are surrounded by invisible walls protecting them from sudden spontaneous change. The height of the wall is measured in terms of energy and the additional push is needed to overcome the wall.

It seems that physics, as if following the advise of Edward Gibbon, found the secret of change in the reasons for stability.

> Instead of inquiring why the Roman empire was destroyed, we should rather be surprised that it had subsisted so long (Gibbon, 1946, Vol.3).

Energy, in most abstract sense, is a measure of the ability of spontaneous change. When we contribute energy to a twig, we break it, and if we do that to a stone, it flies away. When we contribute energy to a system, it rises above the invisible walls and jumps over to a new stable state. We do not need to give a push to a bird, however: it takes off and flies away *on its own*. The energy of the bird comes from food and it is stored in a ready to use form. We may need energy to contain the bird and prevent it from escaping by surrounding it with the walls and ceiling of a cage.

Energy of a system, therefore, can greatly vary and even change its sign. A system with negative energy is in a pit, and the walls of the pit prevent the system from transformation.

The system with zero energy can be compared with a ball on a flat horizontal surface: there are no walls and no pit, and under a slight nudge the ball can roll in any direction. We should not forget that it has zero energy only because we said so. In fact, we can place zero anywhere on the scale. What matters is the sign of the change of energy when the system goes from one state to another.

The system with high energy can be compared with a small ball on top of a large ball: there is only one direction of change, and we must spend energy to keep the *status quo*, like the circus acrobat must spend energy to stay on top of a big ball or on tight rope.

Live systems, including society need to consume vast amounts of food and fuel to maintain their balance, while the rocks in a valley can stay there for millennia.

In the case of chemistry, we raise energy of a system by heating it or irradiating with light.

The energy of human society has the same ultimate source as the energy of a bird: food. Here the principle of consilience comes very much to the point. Deprived of the source of energy, a higher organism usually engages in a sort of gambling. Instead of ceasing all activity in order to

save energy, as lower organisms do, it first intensifies the search for food, but if it does not find it, the activity gradually stops and the organism dies.

Social energy, like physical one, is an ability to generate change or prevent it. This is all we need to know about it without any further speculation how to measure it and in what units. It might be a task of social sciences to analyze the origin and transformation of social energy from food and fuel into specific actions.

Unfortunately, physics of society as natural system is underdeveloped, but it would take a whole book to explain why.

In terms of Figure 15.1B, **K** does not simply jump into **M**. First, it has to reach a certain intermediate unstable state **L**, which is high enough above the wall. Then it can roll back to **K** (a revolt fails) or forward to **M** (the revolt succeeds).

The intermediate state **L** is called *transition state* and it is the key to understanding how anything happens in chemistry and material world in general. To apply the concept of transitional state to any system is, with hindsight, not such a big achievement. What is less obvious, the initial, transition, and final states can be portrayed and discussed in terms of configurations and patterns. This could be a radically new idea in humanities, and it seems to have germinated independently in a few places, aside from structuralism of Lévi-Strausse.

Here we often refer to the works of Crane Brinton. His books *A Decade of Revolution* and *The Anatomy of Revolution*, as well as chapters in *A History of Civilization* co-authored by Brinton, are among our main sources of factual material.

As an American historian, Crane Brinton was little biased by European nationalism and political disputes. The fact that the American Revolution was supported by both the King of France and people like Lafayette favors objectivity. Crane Brinton was one of the foremost

American researchers of the French Revolution and he compared it with three other major revolutions: in England, America, and Russia in his *The Anatomy of Revolution* (Brinton, 1966). This array of revolutions is valuable for a pattern hunter.

Brinton's vision of history had a strong pattern flavor. As the following examples illustrate, he compared society with a building and noted the limited character of change produced by revolutions.

> Even at the height of a revolutionary crisis period, more of the old building is left standing than is destroyed (Brinton, 1966, p. 256).

He rejected this metaphor, however, in favor of the following compelling image:

> But the whole metaphor of the building is bad. We may take instead an analogy from the human nervous system, or think of an immensely complicated gridwork of electrical communications. Society then appears as a kind of network of interactions among individuals, interactions for the most part fixed by habit, hardened and perhaps adorned as ritual, dignified into meaning and beauty by the elaborately interwoven strands of interaction we know as law, theology, metaphysics, and similar noble beliefs. Now sometimes many of these interwoven strands of noble beliefs, some even of those of habit and tradition, can be cut out, and others inserted. During the crisis period of our revolutions some such process seems to have taken place; but the whole network itself seems so far never to have been altered suddenly and radically, and even the noble beliefs tend to fit into the network in the same places. [*ibid*., p.256].

In this eloquently "pattern" picture with "strands of interactions" standing for lines, we would remove only the beginning: "But the whole metaphor of the building is bad." As far as buildings are concerned, we have to turn to architecture.

Christopher Alexander developed a general theory of design in his book *Notes on the Synthesis of Form* (Alexander, 1964). Among many compelling ideas of the book we select here only one.
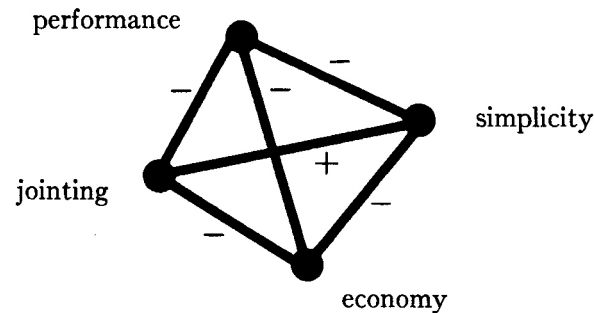

Figure 25.2. Design as points and lines. From Alexander (1964)

Alexander notes that a designer of an object, whether building or tea kettle, has to meet a set of requirements. Some requirements enhance each other and some contradict. For example, the simplicity of design enhances jointing, while decreasing performance.

Figure 15.2, borrowed from Alexander's book, illustrates his idea *in points and lines.* The sum of all conflicting and cooperating requirements represents the stress of the design, which is synonymous with abstract energy as we understand it. In the process of design, the stress must be reduced. Therefore, the entire process of design looks like movement from the initial pre-design state to the final design through a highly stressed transition state.

Clearly, this concept is widely applicable to building such political and economic entities as international coalitions in times of war and peace, European Union, corporations, political parties, and underground terrorist networks. The implications are obvious and we leave them to the reader. We would like to add a quotation:

When we consider the kinds of constructive diagram which are likely to be suggested by sets of

requirements, at first it seems that the nature of these diagrams is very various. Some diagrams seem to define overall pattern properties of the form, like being circular, being low rather than high, being homogeneous. Other diagrams seem to be piecelike rather than patternlike. They define pieces of which the whole form is made, like a diagram defining the street as a piece of the city, or the handle as a piece of the kettle, and so on.

Actually the distinction between patternlike and piecelike diagrams is more apparent than real. Take a simple example, a diagram which specifies a circular plan. Being circular is usually thought of as an overall property of a plan. But the plan's being circular may also be guaranteed by a surrounding wall or boundary of some sort. In other words, we can invest what is apparently a pattern property in a component which is much more of a piece: namely the boundary.

(Alexander, 1964)

Subjectivity seems to be one of the causes of the chasm between sciences and humanities. As we are trying to show here, there is a common ground for both.

Dealing with life in its animal and human form, we can hardly expect the same level of predictability that we have in physical sciences. Nevertheless, we accept the imperfect way natural sciences predict the weather, and we would not mind having even half of that prognostic and interpretive power for the events behind the horizon of time.

We cannot expect, a skeptic could say, to find anything about history with new tricks that the good old common sense would not tell us. This may be true. But common sense tells us that the sun moves around the earth, too.

It is obvious that although graphic presentation of a genealogical tree can save a lot of space and be very helpful in understanding complex kinship, it does not convey any new information as compared with a methodical verbal description. If we are going to use dots and lines for historical representation, they should help us understand something that we have not known or did not pay attention to, or at least add some fun to studying history.

The general idea of this chapter can be summarized as representation of a change of a structure in terms of a certain value that can be estimated from the values of elementary components of the structure. We call it energy because it is similar to physical energy as far as transition from one structure to another is concerned. We realize that there is a big theoretical gap in our understanding what this energy is in social systems and historical transitions. Nevertheless, although it cannot be calculated in any absolute terms, unlike the energy of the falling stone, there could be means of discussing relative energies of two structures or their components in terms of which is larger that the other and with what probability. We will further have more opportunities to present the reader with additional evidence that this general concept is by no means alien to social sciences and humanities in general.

The following general plan of actions can be outlined from what we have discussed:

1. Build a structural representation of a certain system.

2. Consider a state of the system before the change.

3. Consider alternative final states.

3. Build possible transition routs from the initial state through transition states toward final states.

4. Look for the transition states with the highest probability (lowest energy) and find the most probable final states following from them.

If the final state is known, the most probable route speaks for itself as an explanation. If it is not known, the most probable final state is a prediction.

While predictions of mechanics are deterministic, predictions in biology and, all the more, social sciences, are probabilistic.

Instead of speaking in terms of energy that cannot be measured, we can use euphemisms like stabilization and destabilization and say that Germany and Russia were transformed because they were destabilized, but this is not much. We have to show this in pattern terms.

Of course, we have an obligation to comment on the connection between physical energy and social one. The fact that the horse is a vegetarian and has a good appetite contributed to the genesis of the feudal society with knights sitting on significant pieces of land that only all the king's men together could protect. A human is omnivorous, requires much less space to feed himself, and, unlike the horse that needs to be taken a good care of, can somehow get away with a meager sustenance.

The use of mineral energy has been the driving force of the last two centuries and it brought about an immense amount of historical change. We can also imagine a stage in evolution driven by a different trend: diminishing consumption of energy due to a population decline and development of not the moving robots, as the science fiction writers imagine, but miniature computers requiring very little energy as compared with the consequences of their activity. If this trend continues, they could put the humans in the position of the horses. We can already see that the current process of globalization, with both positive and dangerous consequences, has been driven not by armies and heavy machinery but by computers and communication lines.

There is no direct dependence between the consumed food and human energy. Well fed people can be more productive, but hungry crowds could be more active: poor crop was an important factor among the immediate causes of the French revolutions of 1789, 1830, and 1848. The concept of energy is more complicated than it seems at the first glance, however, and we will come back to it in Chapter 26, *Chaos-order, heat-cold*.

At this point we feel the need to build such structural representations that would give us some means to evaluate and compare the structures in terms of a non-structural parameter similar to energy or probability. This can be done within the framework of pattern theory, for which we have finally made all gradual preparations.

The next chapter is, probably, the most technical, and the reader who feels that the intuitive idea of pattern is clear enough, may surrender to difficulties. What history teaches us, however, is to keep fighting.

16. Generators, configurations, patterns

Unlike such mathematical terms as graph, topology, and group of transformations, the word *pattern* is widely used and its meaning seems to be more or less clear from its everyday usage. To avoid the ambiguity of "more or less" we shall try to give an idea of what pattern is in pattern theory.

It seems that neither graphs alone nor groups alone are sufficiently rich structures to extract the regularity from the complexity of the real world with its irreversible dynamics. Thermodynamics underlies all natural sciences, but it is not outright clear whether concepts of energy and entropy could be applied to revolution, reform, and political stagnation because

thermodynamics is known for its intrinsic disregard of structure, while humans are notoriously volatile in their behavior.

Pattern theory is *algebraic* in the sense that it manipulates symbols according to given rules. It is *compositional* in that some of these manipulations consist of combinations of simple parts into more complicated ones. It is *metric* in that it measures the plausibility (or legality) of such combinations in terms of probabilities.

It is therefore a hybrid of algebra, topology, and probability theory.

The starting point of pattern theory is the creation of its simplest building blocks, the generators, a bit like in chemistry. They can be visualized as atoms capable of forming certain bonds with each other and produce "molecular" structures capable of change. An important property of chemical atoms is that they have selective *affinity* to each other, and they have strong preferences regarding what kind of bonds, what number of them, and with what other atoms they can form. Same with generators. They form *configurations* which on the surface look like graphs, but this is only part of the picture. Generators are placed in the nodes of a *connector graph*, and they belong to the same family of objects described by square tables as graphs and groups. There is so much of other data that could be written into the cells, however, that to use tables makes little sense.

In the most general view, generators are a set of objects with rules for connecting them. This is the subject of abstract algebra: the language of mathematics.

A chemist might say that configurations are molecules built of atomic generators, but a mathematician would object that this picture is turned upside down from the mathematical point of view: molecules are configurations built of atomic generators, and so are graph, dance, poem, engine, society, genealogy, myth, novel, house, fabric, wallpaper pattern, and there is no end to

the list. From the point of view of pattern theory, chemistry is just one of many illustrations of pattern theory.

Although we compare generator with an atom of knowledge, this atom, like the physical one, is not simple. A stricter pictorial description of the generator is shown in Figure 16.1.

Generators have *identifiers* labeling them as distinct from one another. They also have *bonds,* also identified by indexes.

Identifier is, actually, a name, and a generator may have several names, all arranged hierarchically, like first name, middle name, and last name. It can be as short as H_8 (compare with Henry VIII) or long, including gender and title, like Helmuth Karl Bernhard Graf von Moltke (German general known as Moltke Senior), and the magnificent Emilia Condesa de Pardo Bazán de Quiroga (Spanish writer). Bonds also have their own names, *bond indexes*, and *bond values*.

In Figure 16.1 generator **A** has two bonds numbered by bond indexes **j**=1 and 2. **B** has three bonds, **j**=1, 2, and 3. The half-circles at the distal ends of the bonds are added to visualize the connection or coupling of generators, symbolized by a complete circle. The lower part of the figure presents the same connection without mathematical symbolism.

While the indexes (**j**=1,2,3...) are used to distinguish between different bonds, a set *of bond values* β= a, b, c... is used to attribute various properties to the bonds. Thus, two different bonds can have the same or different bond value.

A pair of bonds is characterized by bond relation ρ , for example, EQUAL (bond values are identical) or UNEQUAL.
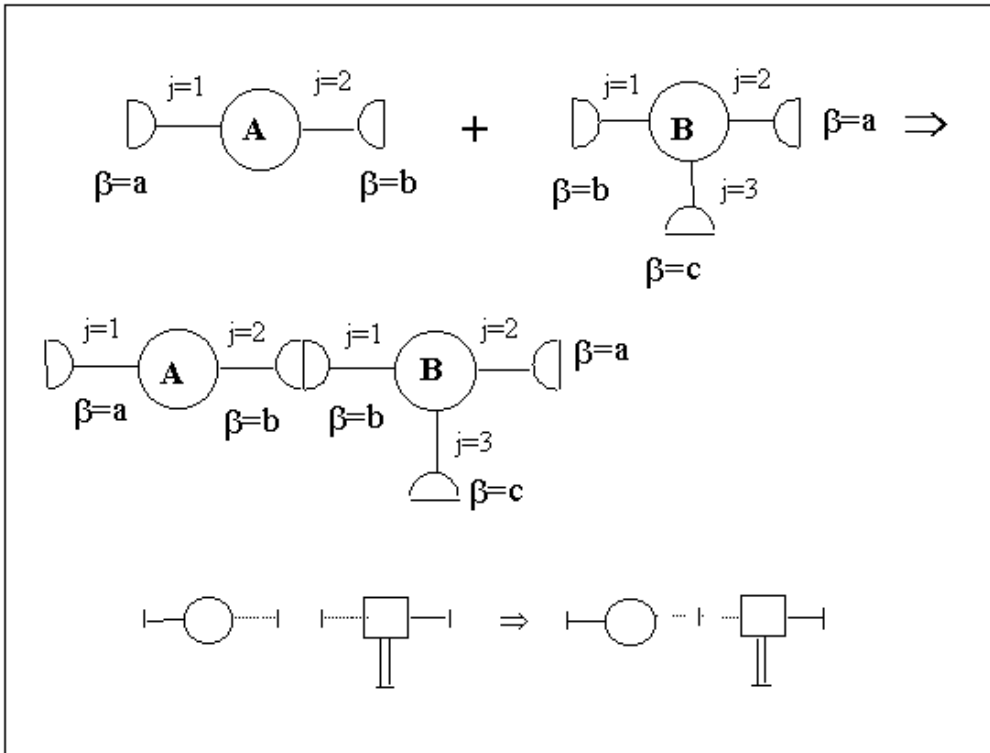
Figure 16.1. Regular connection between generators

The connections between the bonds can be *regular or irregular*, as compared against the standard bond relation set as regular. In Figure 16.1 the regular bond relation is EQUAL, which means that the bond values of the coupled bonds should be the same for the connection to be regular. We may say metaphorically, that the bonds of the same value have an affinity for each other and stick together as if their half circles were covered with glue.

We started our discourse in Chapter 1 with similarities attracting each other. Like our ancestors, we employ here the natural way to introduce order in connections between generators: connections between similar bonds are regular. Like the Toradjas of Celebes, who believed that a bone of a deer would attract the live deer, we make the bonds with same bond values to attract each. "Deer" is the bond value of this case, regardless of anything else.

As a matter of fact, the rule of regularity can be any. We can set the bond relation as UNEQUAL, for example, so that all bonds but those with the same bond values are allowed to couple. We select the rules of regularity in order to give the simplest mathematical representation of the object.
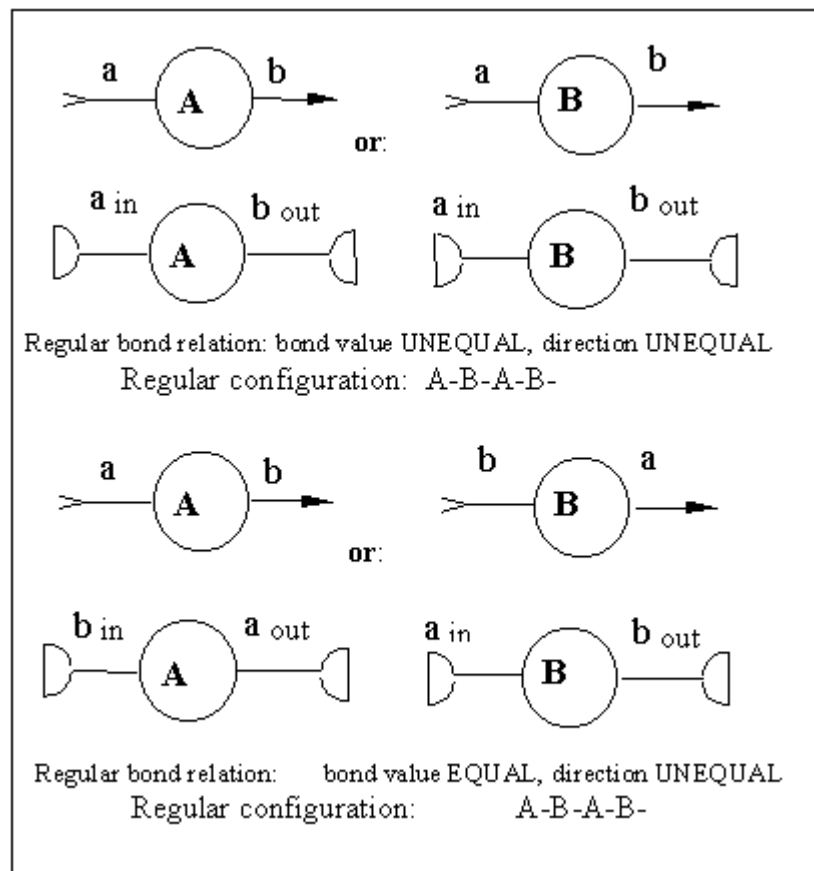

Figure 16.2. Regularity and oriented bonds

Bonds can also have direction, for example, outbound and inbound ones. Some cases of regularity of directed bonds are shown in Figure 16.2, where two different sets of conditions of regularity result in the same regular configuration **A-B-A-B-**....

Configurations possess two kinds of regularity. One is the local regularity, which we have just described. It determines which connections are "lawful" and which "deviant" through bond relation ρ.
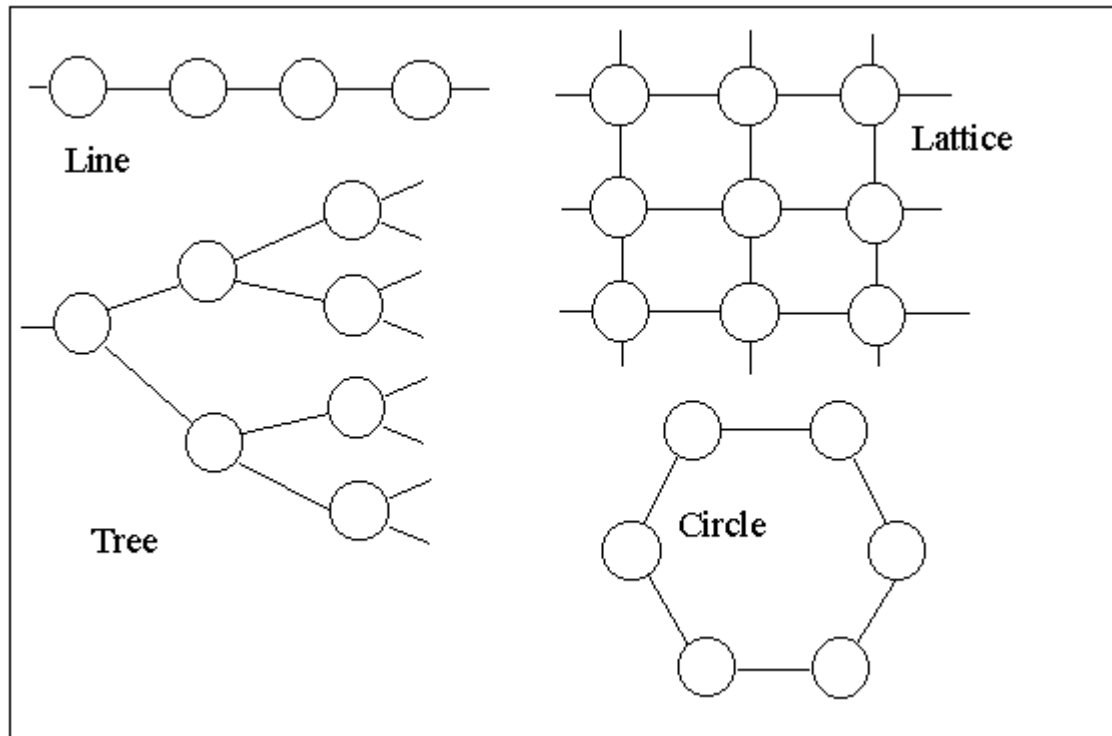

Figure 16-3. Connectors

The global regularity Σ may take form of a specific connector graph, such as LINEAR, TREE, LATTICE, CIRCLE, etc., Figure 16.3. A regular connector could be defined as having or lacking some topological elements, for example, any graph with outstanding bonds or without cycles.

Next, generators fill up a certain generator space **G**, a collection of generators, which is, so to say, a Periodic Table of building blocks. This space can be partitioned into subspaces **G₁, G₂** , etc., as the Periodic Table is partitioned into groups. For example, all social generators are

human, but they are partitioned into male and female, children and adults, Chinese and
Barbarians, etc.

We can set a condition of regularity as the same generator subspace, as with members of
warring clans, Montegu and Capulet.

Finally, regularity includes similarity transformation **S**, which defines how we can
deform a configuration without violating its regularity. Examples of **S** were given in Chapters 6
to 8. Transformation from *Romeo and Juliet* to *Westside Story*, Figure 8.7, was one of them.

It is easy to define chaos and irregularity as anything possible. We increase regularity by
imposing more and more limitations on what is possible in four domains of pattern definition.

Let us take as an example the property of "pearness," see Figures 7.1 and 16.4, that
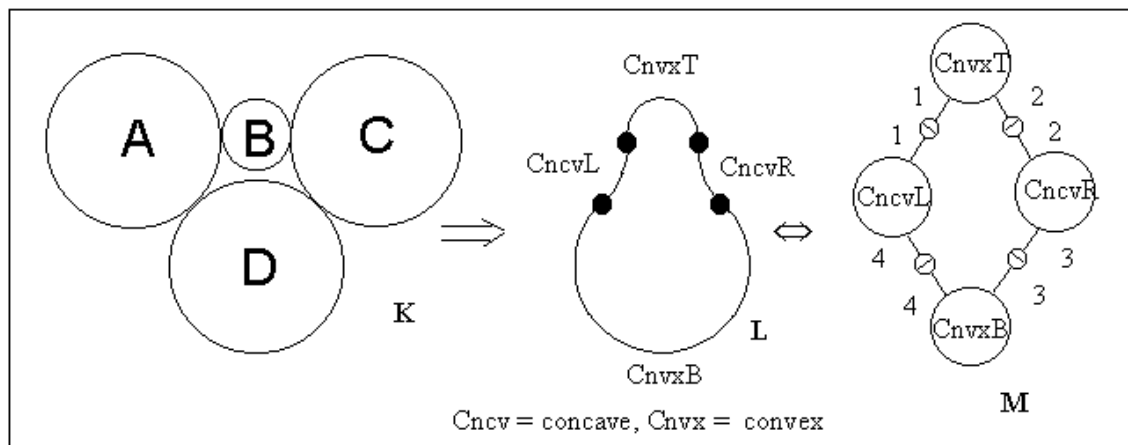Louis-Philippe was said to have.

Figure 16.4. Pearness

We can construct the pear-like shape using four arcs derived from circles **A-C**, two of
them convex, **CnvxT** and **CnvxB** (top and bottom) and two concave, **CncvL** and **CncvR** (left
and right). Regarding the arcs as generators with two bonds each, with values from 1 to 4, we

can connect them as in Figure 16.4M. This configuration will be locally regular with bond relation EQUAL, and we do not even need to specify the connector.

We can obtain all pear-like closed curves by taking any of them as a *template* and deforming the arcs by changing their radii, length, and shape. We can, therefore, *synthesize* a series of configurations of the same pattern, starting with any of them, and applying a group of transformations. Of course, first we have to *analyze* a couple of particular configurations in order to define their generators. Pattern analysis results in defining regularity on the basis of selected observations of images and configurations behind them, while pattern synthesis generates regular configurations—whether familiar or never observed—from the definition of regularity. Using this we can also evaluate the degree of irregularity of a configuration.

For example, we can define the regularity of an X-ray image of the normal stomach and recognize an abnormality on a new image never seen before, or measure the irregularity of potato shape picked by a digital camera. Applications like that constitute the main body of pattern theory. It is a complex mathematical discipline and all we can do here is to present its basic ideas in a simplified form.

We had to spend some time on such things as topology, graphs, groups, and probability to demonstrate that they were not as intimidating as they might seem and the humanities had been playing with them for the entire century.

From the densely mathematical atmosphere of pattern theory we make our cavalry raids into the open spaces of history, looking for its big potatoes and pears. We would like to convey to the reader a realization that some most fundamental mathematical concepts may hover like Valkyrias over the battlefields of history, street barricades, and signing ceremonies, as well as over the routine of our everyday life.

In the majority of practical applications of pattern theory, such as image recognition and restoration, the objects exist in metric space where they can be transformed as geometric figures. Deformations of geometrical objects form groups. This is why the mathematical apparatus of group theory can be widely used there.

In order to analyze a pattern, we may need to define the similarity transformation, but not necessarily in an analytical form, i.e., as formulas and equations. It can be done through algorithms, i.e., sequences of instructions.

To calculate area of a plot of land, we apply operation of multiplication to the length and width. To make cookies we apply algorithm COOKIE to flower, sugar, butter, and spices.

It is easy to do starting with the portrait of Louis Philippe, filling up the picture with ink, turning it into a silhouette, smoothing the contour, and then removing the fill. It is very difficult, however, to make it the other way around and transform a pear-like closed curve into either a human portrait or a pear unless we already have the pictures available for copying. We cannot imagine an avocado if we have never seen it, although it has the shape of a pear. There is some uncertainty, therefore, whether similarity transformation is always a group, but the assortment of groups is as stretchable as that of the binary relations.

In general, regularity R is a quadruplet of conditions:

$$\mathbf{R} = \mathbf{<G, \rho, \Sigma, S>}$$, where $\mathbf{G}$ is generator space, ρ bond relation, Σ connector, and $\mathbf{S}$ similarity transformation.

Or, in common, although imprecise language:

Pattern is a set of building blocks, rules to connect them, general architecture, and changes that are allowed.

After all that, we can simply say that *pattern* is a set of all configurations satisfying the requirement of regularity **R**.

This is a very simplified picture. In fact, there are many other subtleties which we omit for the purpose of this book. It is worth mentioning, however, that along with configurations and patterns there is another class of objects, *images*, which can be compared with perceptions of a situation by different observers. Thus, Edmund Burke and Thomas Paine had significantly different views of the French Revolution, but we could reconstruct some information about it even if we had no other sources than their books.

While a configuration is an abstract representation of knowledge, an image is what is observed, not necessarily by the eyes, for example, a historical document such as the Declaration of Rights. There must be something behind the image: we call it configuration. The configuration could be a historian's formal analysis of its ideas. One configuration can project different images, like a body casts different shadows, and several configurations can be perceived as one image.

Pattern theory attempts to formalize the hierarchical relation between sets of configurations identified as images, and sets of images identified as patterns. It aims at formalizing the complete picture: the confusing fuzziness as well as the comforting regularity of both the world and our description of it. Pattern theory, similarly to thermodynamics, harbors both order and disorder, but does it in the way that is complementary to the structure-blind thermodynamics.

If this highly simplified picture still seems complex, it is because pattern theory is designed for mathematical representation of complex objects. There is a minimal complexity of theory that is absolutely necessary to describe an incomparably larger complexity of such objects

as human anatomy or society, all the more, there is nothing else for this purpose except the tedious and subjective verbal description of the objects.

As compared with nodes and arcs of graphs, generators and their connections are much more specialized and we have much less freedom in handling them. This is exactly what they need to serve as building blocks of organized structural complexity.

Here we come to an important difference between the classical structuralism and pattern theory. What the pattern theory uniquely offers is the possibility to include irregularity and dynamics into the general picture.

In other words, which should not be taken too seriously, we have a chance to reconcile structuralism and postmodernism by allowing relaxed regularity as, so to speak, natural phenomenon. In Figure 16.5 configuration **M** would fit the pattern of two other configurations—ρ = **EQUAL,** Σ = **CYCLE**—if not for a single imperfection. Yet we could relax regularity and allow occasional imperfection with a certain probability over a multitude of configurations of the same pattern.

Local regularity, for example, can be defined as the bond relation that can be not only **TRUE** (perfectly regular) or **FALSE** (absolutely irregular) but somewhere in between, for example, 80% **TRUE.** This can be visualized as a pattern swinging between the two extreme states, dwelling 80% time in one of them.

One might ask how can anything be irregular except for discount merchandise? The very notion of nature seems to preclude any irregularity because the variation and deviation from the average is the law of nature and exception is the rule.

As with any very general and fundamental property of nature, regularity has no opposite. Regularity and irregularity, like order and chaos, heat and cold, are not two but one concept, which splits only in the everyday human language and relativistic experience.
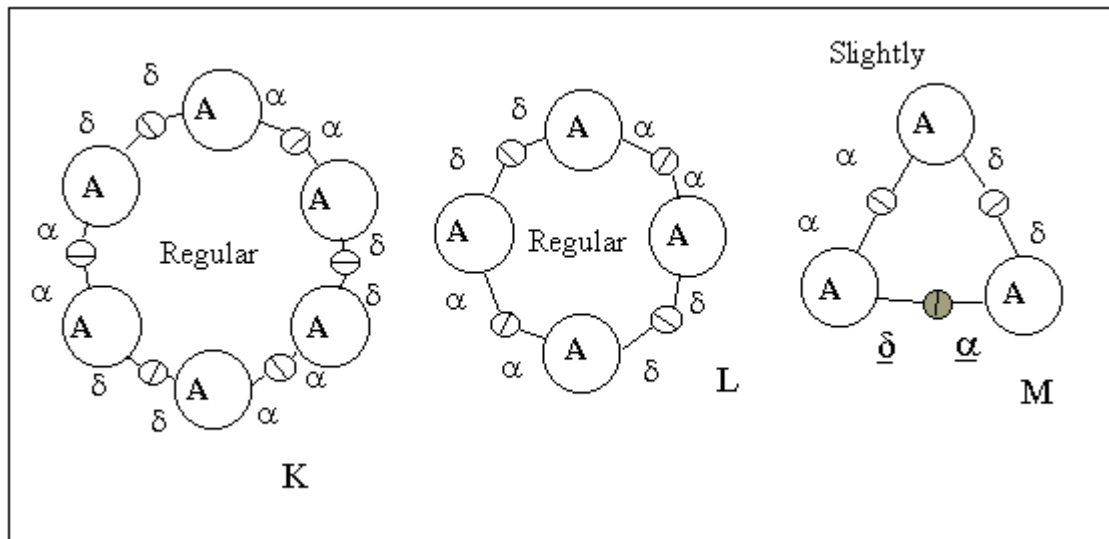

Figure 16.5. Irregularity

As order and chaos are just different degrees of each other, irregularity is just a lower degree of regularity and regularity is nothing but a degree of order.

In physics we express the degree of chaos in a system as its entropy. In pattern theory it can be done in a specific way, as local and global regularity. Thermodynamics deals with large statistical ensembles. Pattern theory is capable of dealing with just a few structures, as well as ensembles.

Irregular things happen all the time in history of civilization, and no evolution, not to mention revolution, can occur without breaking the rules. Any picture of the world would be incomplete without rendering this inherent tolerable chaos.

Entropy (ratio of order and disorder), energy, and temperature are the fundamental concepts of thermodynamics. The ability of pattern theory to take into account and express the degree of regularity (order) gives us a powerful tool to bring all kinds of configurations and patterns into the same family with physical objects. As we shall see, we can do something like that also regarding energy and even temperature.

17. Law and disorder

The culture of so-called primitive societies displays a diversity of customs, beliefs, and mythology so diverse as if their building blocks had a complete freedom of combination. At a closer look, however, the universal patterns of culture over time and space become evident. Moreover, they are products of evolution of earlier patterns and thus even less arbitrary than they might look.

> Among those opinions which are produced by a little knowledge to be dispelled by a little more, is the belief in an almost boundless creative power of the human imagination. The superficial student, mazed in a crowd of seemingly wild and lawless fancies, which he thinks to have no reason in nature nor pattern in this material world, at first concludes them to be new births from the imagination of the poet, the tale-teller and the seer. But little by little, in what seemed the most spontaneous fiction, a more comprehensive study of the sources of poetry and romance begins to disclose a cause for each fancy, an education that has led up to each train of thought, a store of inherited materials from out of which each province of the poet's land has been shaped, and built over, and peopled. (Tylor, 1958)

In this chapter we would like to illustrate the pattern formalism of Chapter 17 with some selected examples from mythology. Our sources are Beckwith (1970), Bierlein (1994), Cotterell (1989). and Frazer (1981).

Mythology starts, as is appropriate in historical context, with some doctrines about the creation of the world and in particular the beliefs about the first human beings.

Most mythologies assert that it all started with a man and a woman, as Adam and made of his rib Eve of the Bible. Ask and Embla in Nordic mythology were both made by god Odin from ash and elm. In Hawaii the ancestors were Wakea and Papa, who in southern Polynesia were gods of heaven and earth.

The pattern, therefore, is simple: a union between a man and a woman. In Figure 17.1 we show the configurations as circles connected with bond couples. The large circles with names are generators and the bond couples are formed by fusion of small half-circles. Each circle has an identifier (name) and a bond with a label (β). **A** and **B** can be selected from a multitude of names: $\mathbf{a_1, a_2, a_3... b_1, b_2...,}$ while β can be either male (**M**) or female (**F**).

The match of bonds is expressed as bond relation ρ, which can be equal (same β) or unequal (different β). The function of the bond is, just as in chemistry, to regulate which generator can be connected with which, according to the doctrine being formalized. Only combinations **M-F** are allowed in our mythic examples, so that one male and one female "atom" of genesis can form a *bond couple*.

If we label the generators $\mathbf{g_1, g_2, g_3,}$ and $\mathbf{g_4}$ and go no further, it seems that Adam and Embla can form a couple. We cannot couple characters from different mythologies, however, unless in Hollywood movies. We need some means to keep reasonable order among the members of the ancestral club.

In practical terms, we need to attribute more values to the bonds. First, we distinguish between Biblical, Scandinavian, and other mythologies, using label **C** (culture), which can take values such as *b* (Biblical*), s* (Scandinavian*),* etc. Second, we label the bonds with values **S** (sex): *m* and *f*, male and female. Now it is simpler to restrict combinations. We impose regularity by marking their bond values as **C** and **S** and saying that the bond couple between two generators g_k, and g_l is regular (lawful) if $C_k = C_l$ and $S_k \neq S_l$. In common language it means that both should have opposite sex and belong to same mythological system.

Why do we need all the symbols and indexes, so confusing for an untrained eye, if we can say it in plain or, better, artful English?

The answer is that plain English may be fine for mythology and something else, but mathematics is about everything. Since antiquity science have been driven by the search for universal principles and universal language and had to pay for that with exhausting search for minute detail.

It will now be useful to abstract from the incidental to the fundamental and this we do now and in the following by using systematic notation.

After Fernand de Saussure (1974) demonstrated the distance between the *signifiant* (the sign) and *signifié* (what it signifies), notation itself may seem to be of little importance, but that is not so. The reason why it is important is not so much the choice of signs and symbols in a notation, but the decision of *what* to signify. Our choice in this simple case reveals the structure of the object, as well as the approach of pattern theory.
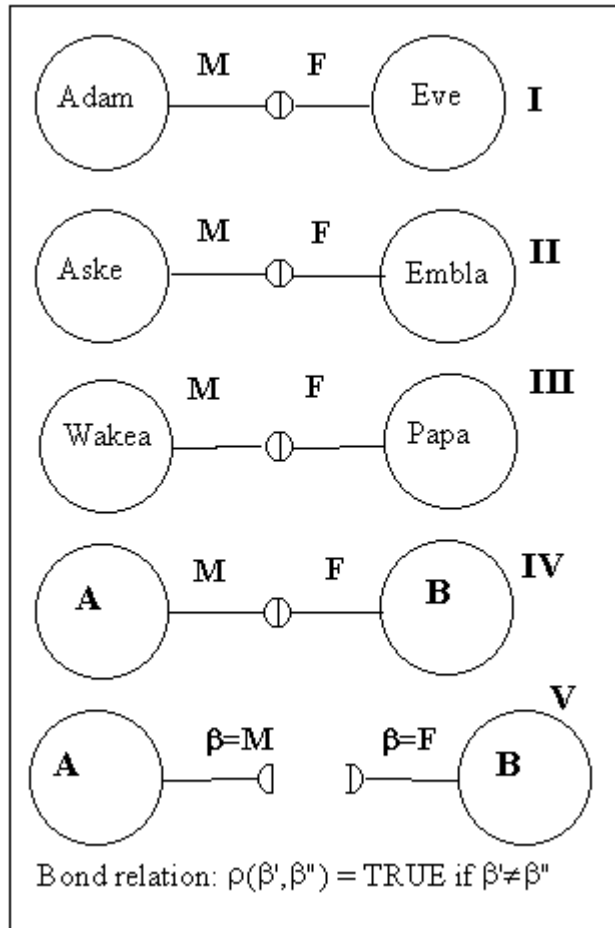
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Figure 17.1. First god-made humans

The circles with bonds are what we call *generators*. Generators are abstract mathematical objects and the circles are strictly for pictorial symbolism. Here they are atoms of marriage. There are two of them, each with its name (identifier) α and bond value β, and the rule (bond relation) that establishes regularity.

The bond relation between two locked bonds with bond values β' and β'' is TRUE: the bond couple is regular, if their bond values are different.

In the mathematical symbolism:

Bond relation: $\rho(\beta',\beta'') = $ TRUE if $\beta' \neq \beta''$

What an esoteric way to say a simple thing: a regular mythological couple consists of a man and a woman. But pattern theory is not intended for simple things. This arcane notation can be fully appreciated only in dealing with the entire overwhelming complexity of the world.

While the pattern man-woman is typical, in Zoroastrian mythology, the first couple was not man and woman but the man Gayomart and his ox. They died, destroyed by a wicked demoness Johi. A tree grown for Gayomart's body split into the first couple Mashya and Mashyane.

It is getting more complicated in Madagascar where two men and a woman came first. One of the men made a statue, the woman turned the statue into a girl, and so first two couples appeared.

The first Pawnee Indians were the daughter of Morning Star and Evening Star and the son of Sun and Moon who became the first human parents.

Con Tiqui, god of Inca, made men and pregnant women out of rock.

In a Talmudic story, Samael (Satan) was a former angel whom God wanted to be the first man. The experiment had been a disappointment and Adam was made from dust. Next came Lilith, who refused to submit to Adam and so could be regarded as the first champion of women's rights. Finally, Eve came.

In this overwhelming variety, the pattern of Figure 17.1 for the first couple is universal. For most stories of genesis the bond relation is unequal.

This brings us to a better understanding what chaos and order are: ultimate chaos means that everything is equally possible, while order means that some limits are imposed on chaos, and ultimate order means that only one alternative of many possible is allowed.

The concept of chaos/order seems quite a useful tool for political and social studies. Designers of a better car engine and a better social order, however, may not realize that they deal with the same kind of objects as anthropologists, even though the engineer calls chaos heat and the politician means by heat an embarrassing situation out of control. We can now say that the ideal of totalitarian society as well as of bureaucracy is absolute order, which is something very far from the nature of things in society, as well as in transportation.

Many nations had their own mythologies with two major coupled protagonists of divine nature, like Zeus and Hera (Greece), Jupiter and Juno (Rome), Odin and Frigg (Scandinavia),

Apsu and Tiamat (Babylon), Baal and Astarte (Phoenicians). We can index now all mythologies as 1, 2, 3..., and we do not even know where the list ends because we may discover a new myth tomorrow.

Here let the generators be denoted abstractly by $\mathbf{g_{1F}}$, $\mathbf{g_{2F}}$, ..., $\mathbf{g_{1M}}$, $\mathbf{g_{2M}}$, ... so that we can form the set **G** of all generators, the *generator space,* that contains the primitives created so far. If we want to express the insignificance of the names, the doctrine should represent both the combination $\mathbf{g_{1F}}$ - $\mathbf{g_{1M}}$ and $\mathbf{g_{2F}}$ - $\mathbf{g_{2M}}$, so that we can permute the subscripts 1 and 2 : $1 \leftrightarrow 2$. Permutation means that we can change 1 to 2 everywhere we encounter 1, and *vice versa*.

As long as two generators are indexed with M and F, the connection is regular.

The similarity transformation that identifies all regular couples as a pattern preserves the mythology index. In other words, we can go from mythology to mythology with the same pattern on the banner.

Note that permutation here is a very simple and clearly defined transformation, very similar to the translation of a triangle in a plane, which changes all coordinates by adding or subtracting the same number, one for all points. We perform translation by moving a book around the table without rotating the book.

Here we come to a very important moment for understanding the core idea of pattern history. Geometry is regarded here not as just drawing points and lines, but, as Felix Klein, the author of Klein group, saw it: a "domain of action" and a group of transformation preserving some properties (see Yaglom, 1988). That was the idea borrowed by structuralism from mathematics. It alone was not sufficient for analysis of historical change that could be compared with a *change from one geometry to another*.

Since we have mentioned the geometrical nature of pattern theory, as well as a wider universal meaning of geometry, we must mention algebra and its wider universal meaning little known outside mathematics. Abstract algebra deals with a *set of objects* S and a finite *set of operations*. An operation takes a single element of S into the same or another single element of S or a couple of elements of S into a single element of S. In this sense pattern theory is an algebraic system: it takes a configuration and turns it into another or it takes two configurations, even as simple as naked generators, and combines them into a third.

Thus understood, mathematics offers a handshake to humanities and the offer was accepted by structuralism. Mathematics studies a general design of the world, whether real or imaginary.

There was, however, a serious reason why the structuralism of Lévi-Strauss was as static as crystallography. Today an anthropologist can study any group of humans: the staff of a physical laboratory or a bunch of computer addicts. Presidential biographers study, in a way, the anthropology of power. Sociologists of poverty study the homeless and the hungry. Lévi-Strauss studied a narrow class of primitive and apparently unchanging *cultures* subject to rigid rules. He drew a line between the static culture and the dynamic *civilization,* and his groups of transformations were designed for the former. He was nor responsible for the lack of insight of his followers.

Thus, we have illustrated with simple examples from mythology all components of regularity: generators, bond relation, similarity transformation, and connector. Next, we are going to show that variance is part of regularity.

The more order we require from the subject of our study the less it seems willing to display it. The deeper we go into the mythological woods the less regular it looks, far from the order of crystal lattice or plant nursery.

There are also other kinship relationships between the characters of a certain pantheon, most important of them are brother-sister and parent-child links. We may add an additional condition that there is no brother-sister kinship between the husband and wife, which is common for all modern societies.

But what if we find a situation where the regularity is violated? Then we can either conclude that our idea about what is regular was too rigorous or we can say that the regularity was somewhat *relaxed*. We can even measure the degree or "strength" of the regularity in percentage—probability, to be accurate—of irregular cases, and if this degree looks high, we have to change our perception of regularity.

Roman mythology seems to possess a certain irregularity. There should not be a brother-sister kinship between husband and wife, but Jupiter and Juno are children of Saturn and Ops and, therefore, brother and sister, as well as husband and wife. However, the similar cases of Osiris and Isis in Egyptian and Ynti and Qulla in Peruvian Inca mythologies show that there is some degree of regularity even in this apparent deviation. We can mention also the eternal conflict between generations, as in the bloody murder of Uranus by his sons Titans.

Brothers do not always get along either, like good Glooskap and evil Malsum, sons of the great Earth Mother in Chippewa mythology, and Abel and Cain in the Bible.

This is what makes cultural anthropology so exciting: we can take a look at the very roots of our civilization, with all its beliefs, customs, deviance, and art, not as a collection of disconnected names engaged in complex acts and relationships but as *patterns*. No wonder that

anthropology, along with linguistics, was the petri dish of structuralism looking for order among chaos.

We have made the very first simple steps toward pattern examination of mythology, the most ancient study of their own history by humans. We see a simple pattern of coupled male and female at the very start of social evolution. By repeating similar steps, we can explore the whole intricate webs of tribal mythologies and discover new regularities. For example, in many of them the two major deities are linked to Sun and Moon (Incas), while in others to Earth and Heaven (Rig-Veda).

The inherent irregularity of factual anthropological data, we may guess, anticipated post-modernism, which differs from structuralism only in focusing on disorder instead of order. We shall take every opportunity, however, to emphasize that chaos and order are not the opposites but, in mythological terms, the two faces of god Janus.

What we can do with patterns is to study their evolution, competition, and selection. Of course, this kind of professional work in anthropology is beyond our abilities, but we hope to stimulate somebody's imagination.

In terms of generators and their bond couples, society is made of the same stuff as molecules, ornaments, ballet figures, etc. This realization may encourage us to import and export knowledge across the borders between scientific domains.

The colorful metaphoric language used by physicist Brian Greene for describing quantum fluctuations to a lay reader (Chapter 14, *Fermentation in wine barrel and society*) is an example of such exchange. Metaphor and imagery are no more contained to be the utensils of fiction.

They are legitimate devices for the explanation across the interscientific borders because they carry patterns. We continue here the quotation:

> Even in an empty region of space—inside an empty box, for example—the uncertainty principle says that the energy and momentum are *uncertain:* They fluctuate between extremes that get larger as the size of the box and the time scale over which it is examined get smaller and smaller. It's as if the region of space inside the box is a compulsive "borrower" of energy and momentum, constantly extracting "loans" from the universe and subsequently "paying" them back (Greene, 1999, p.119)

Another specimen of meaningful metaphoric language belongs to the historian William H. McNeill who wrote in the preface to his book *The Pursuit of Power:*

> *The Pursuit of Power is* meant to be a twin to my earlier book, *Plagues and Peoples.* The latter sought to discern major landmarks in the interaction of human populations and microparasites, paying special attention to the relatively abrupt niche changes that organisms undergo from time to time when some new mutation or penetration of a new geographical environment allows then to escape briefly from older ecological limits. This book undertakes a similar inquiry into changes in patterns of macro-parasitism among human kind. Disease germs are the most important microparasites humans have to deal with. Our only significant macroparasites are other men who, by specializing in violence, are able to secure a living without themselves producing the food and other commodities they consume. Hence a study of macroparasitism among human populations turns into a study of the organization of armed force with special attention to changes in the kinds of equipment warriors used. Alterations in armaments resemble genetic mutations of microorganisms in the sense that they may, from time to time, open new geographic zones for exploitation, or break down older limits upon the exercise of force within the host society itself (McNeil, 1982, p.vii)

Unlike consilience, with its limited communication between the adjacent floors of knowledge, pattern theory treats all areas of knowledge as interconnected global community. By no means want we to diminish reductionism which is the only way to understand a phenomenon

in all its detail. But we need other complementary views of the world to understand the place of the phenomenon in the universe. Globalization of knowledge is as much a sign of our times as globalization of economics.

If we succeed in building the common structural platform and classify regular structures, we can import across the borders not only answers but also *questions* about dynamics, similar to those asked by Galileo and some future observer Ted Buckley III:

Galileo: Why do two stones fall to the ground from the Tower of Pisa, and will they rich the ground at the same time although one is a small pebble, and another is a cobblestone?

Ted Buckley III: Why do two communities of nations, Western Europe and developing nations move along different patterns of evolution, one toward integration and the other toward dissociation, and whether they will ever converge?

Can history be irregular?

Here we would like to refer to Vilfredo Pareto, a highly original Italian sociologist of the first half of 19th century. Crane Brinton thus compacted some of his ideas in a historical context.

What does move men in society, and keeps them together in society, says Pareto, is the *residues*. These are expressions of relatively permanent, abiding sentiments in men, expressions that usually have to be separated from the part that is actually a derivation, which may change greatly and even quickly. Pagan Greek sailors sacrificed to Poseidon, god of the sea, before setting out on a voyage; Christian Greek sailors a few centuries later prayed, lighted candles, and made vows to the Virgin Mary just before sailing. The *derivations* are the explanations of what Poseidon and the Virgin respectively do. They vary. The believer in the Virgin thinks his pagan predecessor was dead wrong. The *residues* are the needs to secure divine aid and comfort in a difficult

undertaking, and to perform certain ritual acts that give the performer assurance of such aid and comfort. The residues are nearly the same for our two sets of sailors.

Both the pagans and the Christians have the same social and psychological needs and satisfy them in much the same ways, though with very different explanations of what they are doing.

Two of the major classes of residues Pareto distinguishes stand out, and help form his philosophy of history. These are persistent aggregates (conservatives) and instinct for combinations (novelty, adventure) (Brinton, 1967, p.367)

This passage could be taken for yet another example of similarity transformation from the pagan to the Christian system of beliefs related to the pattern of securing a safe venture. It leads us further, however, to an idea that everything in society is regular until a change comes, which breaks up the former pattern and establishes a new one. This process first can be described as the appearance of irregularity. When the pattern changes, what was regular before becomes irregular. With time, a new standard of regularity spreads. From a distance in time, we pay more attention to the persistence of the pattern, but we could be equally fascinated by the catastrophic change that the transition from paganism to monotheism meant for those who experienced it. We can actually see how the stability of some patterns helped to maintain balance when others changed. History rarely runs: it walks, one leg at a time in the air, the other on the ground.

Crane Brinton was definitely a pattern historian.

We can see a similar situation in one of the most catastrophic revolutions of the twentieth century, the Russian Communist Revolution. It apparently succeeded in a complete destruction of the centuries old patterns of absolute monarchy and values of a peasant state, physically destroyed the old social generators, but quickly rebuilt the patterns of worshipping the leader with absolute power, centralized system of government, and submissive attitude toward it.

Two of the most striking examples are global economy and the change in the status of women in developed societies. Discrimination of women had been regular for most of the twentieth century, but it became an irregularity during the century's last quarter, when the pattern changed. For most of the century, it was unthinkable for business competitors to help each other, while now we witness the phenomenon of bailing out the sinking rival economies at home and abroad.

This brings us to the view of evolutionary irregularity as a deep deformation of social template under stress and its subsequent rearrangement. A configuration can not only jump from one connector to another but also oscillate between two patterns, as it was with monarchy and republic in France after the Revolution.

> For the entire history of nineteenth-century France can be seen as a struggle between Revolution and restoration, passing through various episodes in 1815, 1830, 1848, 1851, 1870, the Commune and 16 May 1877 (Furet, 1981, p.4).

An eloquent passage from Erica Jong makes you feel the incessant tremor of cultural values in America, albeit only on the surface:

> What a roller coaster ride it's been! Our gender went in and out of style as hems went up and down and up and down and up again, as feminism rose and fell and rose and fell and rose again, as motherhood was blessed then damned then blessed then damned then blessed again. (Jong, 1994, p.xx).

When the deformation changes the radius of a circle, it preserves the form. The deformation of circle into ellipse preserves the topology. Even the transformation of a circle into a triangle (homeomorphism) preserves some topological properties. Breaking the circle into an

open arc, however, is a radical heteromorphic transformation, which cannot be described by a group.

We can discover regularity mostly within a stable period of history. It was regular for feudalism to provide military service to the king in exchange for the right to possess land and have individual protection. Monarchy as power became irregular after a series of European revolutions and world wars, but monarchy as a national institution stabilized. This is how historical patterns change, and the patterns of national mentality are among the slowest to change.

Figure 17.2. Cartoon by David Low

Pattern history, therefore, is as much history of regularity as of its reformulation.

Another sort of example is intended to indicate that drastic and sudden changes do not need to be heteromorphic, i.e., changing the connector. We use Nazi Germany (**NG**) and Soviet Union (**SU**) before the WW2 as generators. Both countries had very hostile relations that changed overnight with the signing of the Hitler-Stalin Pact.

$$\textbf{NG}—(\text{enmity})—\textbf{SU} \ \Rightarrow \ \textbf{NG}—(\text{friendship})—\textbf{SU}$$

NOTE: The following small detail illustrates how much the precious flavor of history is beyond any theoretical grandeur. During the love affair, right before Hitler attacked Russia, Stalin agreed to pay Germany $7.5 million dollars in gold to keep a tiny piece of land in Lithuania that the treaty assigned to Germany. It was the same price that USA paid Russia for Alaska. (G.Weinberg, 1994, p.198).

This remarkable change, immortalized by David Low, Figure 17.2, was *automorphic* since the regularity of the connector was preserved. It was also reversible, as the German invasion of Russia on June 22, 1941, confirmed. A similar automorphic transformation was mentioned in Chapter 3 in connection with the incorporation of Normandy into France.
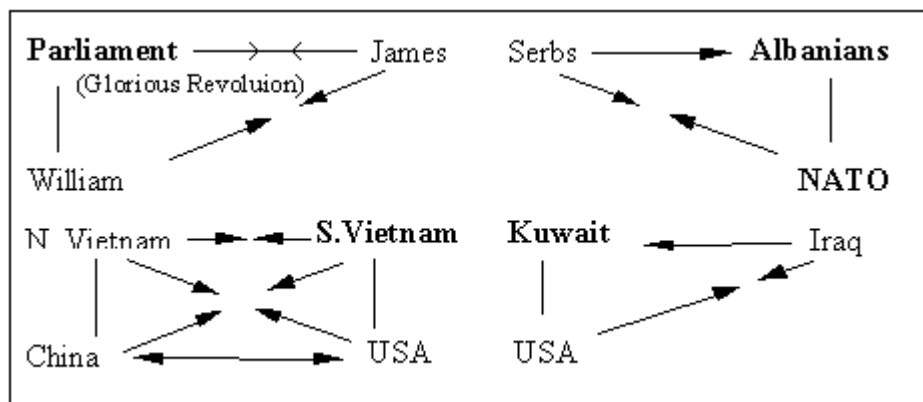

Figure 17.3. Triangles of conflict

Curiously, another simple pattern, the triangle, also transcends the border between love and hate, see Figure 17.3. Those are patterns of resolving a conflict by initiating another conflict.

In the Glorious Revolution, the parliament disposed of James II by arranging the conflict between him and William. North Vietnam and South Vietnam involved China and USA in their war. In the Gulf War, Kuwait easily got USA on its side against Iraq and the Albanians of Kosovo invoked the intervention of NATO against Serbia. In all such configurations, hardly any two sides feel any love toward each other. Some participants of the anti-terrorist alliance of 2001 found themselves locked in the same triangle.

This brings us closer to the analysis of conflict. As the cartoon illustrates, the conflict is a binding relationship and the sides are literally "tied up in a conflict." Both conflict and dysfunctional marriage are as much repulsion as attraction. In the Muslim world, the draw to American way of life, movies, and pop music easily gets together with political animosity.

 Conflict is a permanent dimension of history, and we will examine it in the next chapter.

18. Conflict

On the scale of decades and centuries, we perceive history in such terms as big movement of armed people, development of institutions of religion and government, long-time cultural change, modernism of the twentieth century, and life cycle of large ideas such as capitalism, socialism, and individualism.

On the time scale of years and decades, history is a sequence of changes more localized in time in space. Some of them are important peaceful reforms that look as easy as rearranging furniture in a room, while others are conflicts, some as mild as the family arguments about furniture, some deadly.

If Plautus is right and man is a wolf to any other man then human relations can often be expected to be antagonistic. Human history is indeed full of tales about hostile encounters between individuals, classes, and nations, in which rivalry and envy have led sometimes to violent revolution, sometimes to reconciliation.

Conflicts usually involve two sides or camps. They start with drawing a line in the sand between themselves and end with the recognition of a winner.

From the pattern perspective, conflict is a bond couple, although it may look that the conflicting sides do all they can to break up. Two contestants, however, like two boxers in the ring or two baseball teams in the field, are firmly tied together and neither can leave without a clear and immediate defeat. The violent conflict usually ends with an elimination of the adversary, which during most of human history used to mean death, slavery, or captivity. If there is a formal draw, it rarely means a complete equality of the outcome for both sides because any peace treaty leaves the sides with unequal frustration and desire to replay the game.

Family conflicts can often take extreme forms exactly because the participants, roped-in by the ties of kinship, cannot leave the ring.

> Interested observers of close relationships, as most of us are, are often perplexed by examples of apparently mundane events triggering serious interpersonal conflicts. Is the fabric of our closest, most intimate relationships really so fragile? Paradoxically, researchers suggest that the potential for conflicts of interests increases precisely because of the strength and diversity of the bonds that connect two individuals (Holmes, 1996, p.622)

While chemical structure changes so that no atom is created or destroyed, the inherent property of life is birth and death. Historical changes include emergence and elimination of building blocks and whole structures, down to individuals.

Conflict does not always involve ill intent, but on the bloody stretches of history, in secret political decisions, and in criminal novels elimination is a euphemism for death. In international conflicts, elimination may mean total occupation, seizure, subjugation, and acquisition of territory. Land cannot be physically destroyed, however, and geopolitical

elimination is, in principle, reversible. In our times it is equally difficult to destroy a national spirit, although nations can fuse, hybridize, and split.

There is a more general form of conflict, however, where elimination is not physical: competition.

Competition and selection occupy the center stage in Darwinian evolution, economics, politics, and personal relations. It happens in lottery, when the selection of winning tickets is done at random, in creative games like chess, where it depends on the skills of the players more than on chance, in awards, like Nobel Prize and Oscar, and in all cases of political and economic competition where there the number of prizes is less than the number of contenders. We might blame animals for the conflictive nature that they passed onto humans, but, for better or worse, competition in its many forms is inherent part of modern life.

Elimination, therefore, or narrowing the set, is the very essence of competition. "For many be called, but few chosen" (Matthew, 20:16). There should be a general mathematical description for this general phenomenon. Yet we can only say that, mathematically, the essence of the competition is that a subset of a larger set is *selected,* thereby falling into a vicious cycle. The causality of the elementary act of selection seems to be beyond mathematics. First, somebody must cast a die, and then the mathematics can say something about it.

Two opposite trends are seen in history. One was to narrow the base of competition and select very few from a few. It was typical for aristocratic and autocratic societies. The development of modern democracies initiated an opposite trend, so that a few can be chosen from a very large base. This expansion of the eligibility to compete at the high level has been the major trend in the West since Britain's Bill of Rights. From the United States of America to the

Communist Russia the right to participate in the contest and go to the very top was made universal, although the boxing matches were conducted by very different rules.

We can see the same modern principle of broadening the selection base implemented in the ancient Chinese democratic system of exams for administrative positions. The opposite tendency to limit competition in certain areas, for example, the military service, to a certain social stratum or caste is also very old: some most able defenders of Roman Empire against Barbarians could not become emperors because of their Germanic origin and the presidential election between two candidates seems curiously elitist.

We tend to perceive the broad eligibility to social competition as a manifestation of moral progress and good will, but it can be also a simple consequence of the economic independence. A voting slave is a contradiction in terms because he depends on his master.

We can conclude that the trend to level the playing field is the general trend of the last millennium as a whole. As always, the trend swings. For example, social promotion in schools is an attempt to limit competition, and quotas are aimed at warping the game field to achieve certain social effects.

The idea of equal opportunities can be pushed even further to the idea of equal results. This is the old Communist and, probably, even original Christian idea, never implemented in practice, but theoretically possible in a society of clones. Not accidentally, enormous efforts were made in Communist countries to standardize individuals by indoctrination, force, and controlled consumption.

Is conflict really a bond? The word *bond* associates with a mutual attraction, but the sides of a conflict are bound with the desire to destroy or damage each other. The absence of bond means that the sides are not aware of each other's existence. This is certainly not the case in wars

and feuds: the opponents are most of all preoccupied with the other side, and this obsession of hate is comparable only with the obsession of love.
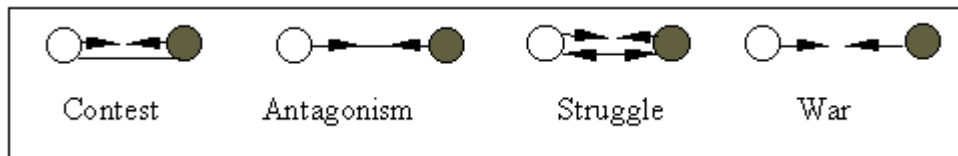

Figure 18-1. Symbols of conflict

We have already mentioned the distinction between positive and negative bonds. The role of both for maintaining social structures was elaborated by cultural anthropology and social psychology. In our terms, positive bonds require energy or effort to break, while negative bonds need the same to keep the two generators together. Neutral bonds require a very low or no energy to either break or establish. The light switch is an example: an equally small effort is needed to either break or close the circuit.

However paradoxically it may sound, conflict is a bond and we have to find an appropriate symbol for it. It is not a negative bond because external efforts are not needed to keep the conflict burning, just the opposite: in our times, efforts are needed to break the conflict. Negative bond means that the generators split as soon as there is nothing to keep them together. When one side of the conflict retreats, however, the other one pursues it with double energy.

We can use different symbols for conflict, such as for example, in Figure 18.1

The possible outcomes of conflict are shown in Figure 18.2.

We can also portray the range from attraction to conflict to war and elimination as we did in Chapter 3:

$$a \underline{\quad} b \Rightarrow a \cdots\cdots b \Rightarrow a \longleftrightarrow b \Rightarrow a \rightarrow\leftarrow b \Rightarrow a \rightarrow \leftarrow b \Rightarrow$$
attraction indifference   animosity   conflict   war

$$\Rightarrow a \longrightarrow b \Rightarrow a$$
 domination   elimination
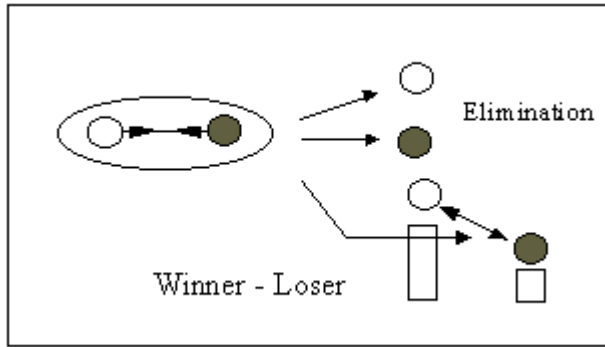
Figure 18.2. Outcomes of a conflict

Figure 18.3. An ancient conflict

Domination $a \longrightarrow b$ is a possible outcome of a conflict and a form of a negative bond where one side spends energy to limit the freedom of the other.

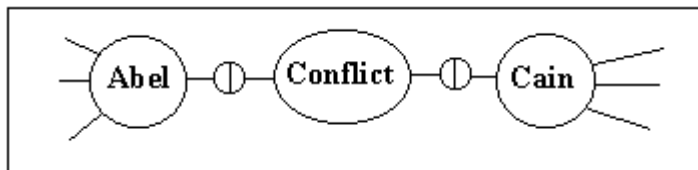This range comprises the whole Cain-Abel conflict, although we know only about the beginning and the end. To portray it, instead of pictography, we can simply insert the generator of conflict between the sides (Figure 18.3).

When Cain saw that his sacrifice was not as well received as that of his brother's, he slew Abel, resolving this conflict was resolved by a violent action.

The sad event depicted in Figure 18.3 has been repeated innumerable times with smaller or bigger modifications, it is a cliché in murder stories and soap operas, and it appears with loftier artistic ambitions in *belles-lettres,* but the ingredients are the same. In the traditional English story, for example, the first-born son of the owner of the estate is going to inherit it - the principle of *primogeniture.* Not surprisingly, the second son is dissatisfied with this state of affairs and decides to change it. When the conflict becomes acute, due to the father's health

deteriorating, he murders the brother, so that we have essentially the same old story, now told for the entertainment of the reader.
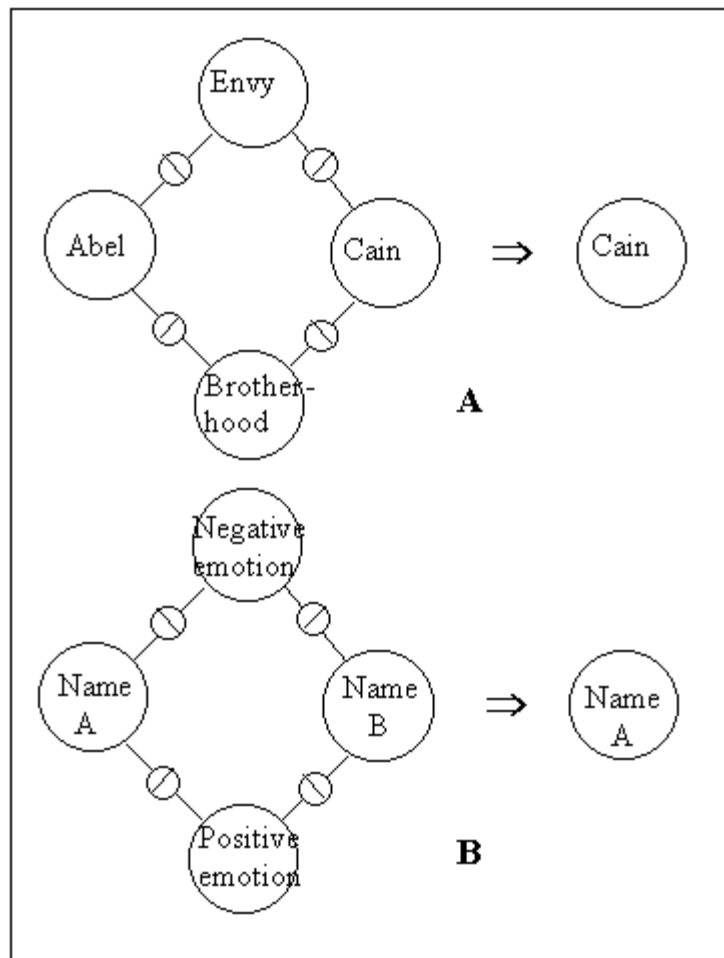

Figure 18-4. Jealousy

We can therefore think of the entire set of such tales as forming a pattern but now involving events in time: human dynamics. Figure 18.3 does not portray the dynamics of the fast-pacing conflict.

The diagrams in Figure 18.4 represent the pattern of fratricidal events, generalizing the Cain and Abel story to any murder of jealousy.

Let us consider some examples of historical conflicts. It is appropriate to remind how often genealogy and kinship created conflicts and "eliminations" in earlier history.

The One Hundred Years War can be reduced to the general pattern of kinship conflict represented by the Abel-Cain story, if we consider the stable sub-configurations of entire houses of Valois and Plantagenet as separate generators.

Two patterns connected with a symbol of transformation ($\Rightarrow$) form a single pattern of a different class: the pattern of change. In this way, we can present the dynamics of a situation in

the same way the frames of animations present motion. We have no approach, however, to find out why Cain was aggressive and Abel was not, or who was the most probable winner of the One Hundred Years War.
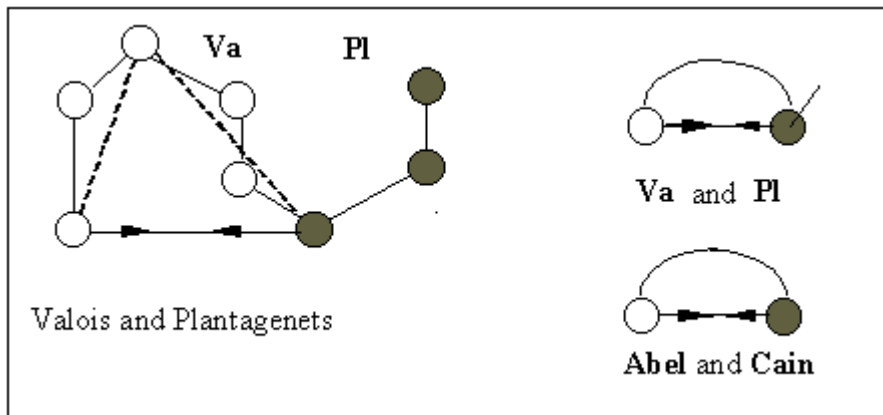

Figure 18.5. Kinship conflict. Compare with Figure 10.2.

Here is a list of some probable causes of conflicts

1. Natural cause (bad crop, birth of a heir).

2. Authoritarian ambitions.

3. Fear of consequences of an external event.

4. Desire to take advantage of an external event.

5. Internal growth, pressure to expand.

6. Internal decline, pressure to stop it.

7. Ambitions of a charismatic person.

It is not clear how ambitions can change structure and it is hard to see at this point how such concepts as energy, effort, and work can be defined in the structural framework of pattern theory.

We shall put off the discussion of this problem until later. Here we would like to indicate that a dynamic pattern has a set of specific dynamic generators, which can be regarded as operations on patterns involving the change of the connector. Surprisingly—but not to a chemist—there is a very limited number of them:

1. ADD, which connects a new generator to an existing configuration.

1. DELETE, which removes a generator or sub-configuration.

2. OPEN, that removes a connection (edge), i.e., breaks a bond couple.

3. CLOSE, that connects two generators.

5. REPLACE, which changes one generator into another, for example in royal succession.

Note, that all of them manipulate with a single entity, either identifier or a bond couple. In this way, we can significantly simplify the problem of transformation and analyze it one operation at a time. We may assume that every step of a transformation of a complex social configuration is mostly local.

If stages of complex social processes are really sequences of very simple elementary changes localized in a few generators and bond couples at a time, similar to mechanisms of chemical reactions, we would find the Ariadne's thread leading us out of the labyrinth of complexity, and, probably, right into the perils of oversimplification. We can immediately test this newly found tool.

19. Testing the Ariadne's thread

Next, we shall try to build a pattern snapshot of Northern Europe on the eve of the Great Northern War (1700-1721). Although we follow the sources (Grey, 1960, Hatton, 1968, Scott, 1988) our construct should be regarded not as historically true but, to use the correct pattern term, an *image*.

What we attempt to assemble is a piece of semantic network translated into pattern terms, and, therefore, we have to start with a short narrative.

The Great Northern War was remarkable in many ways. The theater of war stretched across the entire Eastern Europe from Sweden to the Balkans. It was as much a war of diplomacy as of destruction, treachery, and deceit, and as much a war of joint interests, alliances and propaganda as of weaponry, clever military engineering combined with the tactics of scorched earth, fierce attacks spaced by long idleness, and a medieval mix of both chivalrous respect and grisly cruelty toward the enemy. It coincided and overlapped with another European war crossing the continent west to east—the War of Spanish Succession (1701-1714). In a sense, it

was WW0. Even France had some hand in the events by prompting the unwilling Turkey to go to war to Russia. Without the peace in the south, Russia could not fight in the north.

The Northern War set some remarkable personalities against each other: Charles XII, the teenager King of Sweden, Augustus, the King of Saxony-Poland, and Peter I, the Czar of Russia.

> It is, indeed, difficult to avoid comparing the entertainments of the three chief participants in the Northern War; Charles riding horses to death, beheading sheep and goats, and waging war; Augustus, with his reputed 260 illegitimate children, straightening horse-shoes and rolling silver plates with his bare hands; Peter building ships, making fireworks, mastering various crafts, and relaxing in marathon drinking bouts (Grey, 1960, p. 174).

To this we have to add that Peter I ordered and attended torture and mass executions, and once enjoyed watching 109 Russian heads—human, not animal—rolling down into a trench.

Peter I remains one of a few central figures of Russian history, whose heritage is clearly sensible even today. Russian society has always been split over his role. Similarly, Charles XII gave Sweden a push in a new direction. Later Swedish intellectuals were split over his heritage, too.

> What manner of man was this who blazed through Europe like a meteor? He was a fascinating enigma: as a soldier, he was a genius in quick decision and unexpected action, as the director of the fate of a nation he brought disaster. He had more persistence than adaptability, more bravery than finesse, more military genius than political *savoir faire*. (Scott, 1988, p. 225).

We also have to add to the royal company Johan Patkul, a Livonian baron, descendant of the Order of Teutonic Knights, mistrusted by Peter, betrayed by Augusts, and cruelly executed by Charles. Patkul's head was cut off only at the third strike of the ax.

Patkul was often scarcely or superficially described by many historians but Ian Grey, who does not take sides in his book on Peter I, portrays him in the following way:

Johan Patkul was a remarkable man who flashed across the northern sky like a minor comet. He made his mark on the European scene, even though at the end of the seventeenth century it was crowded with outstanding men and women. Handsome, powerfully built, and possessing a strong personality as well as great courage and energy, he was a dynamic figure. He spoke several languages, could write gracefully in Greek and Latin, and was learned in the sciences of war and politics, as they were then known. By temperament, he was ardent, single-minded, irascible and hotheaded. He could be ruthless and arrogant, and he was indefatigable in pursuit of revenge (Grey, 1988, p. 157).

Some older Russian sources treat Patkul with unexplainable contempt. A fundamental history of Russia written in the Soviet time did not mention him at all.

Franklin D. Scott, author of a history of Sweden, calls Patkul "the man who stirred the witches' brew at the end of the seventeen century." Anyway, the cauldron and all ingredients for the brew were on hand, as Figure 19.1 shows.

Instead of a customary map of the northern skies crossed by meteors and comets, we use a graph reflecting the earthly topology of the various protagonists of the war, and if it looks complex, this is exactly the point. The Baltic coast and adjacent areas were the Balkans of that time: a patchwork of kingdoms and principalities, often in several separate pieces, interspersed with each other.

Europe in 1700 was charged with mutual mistrust and animosity and temporary peace was possible only because of the balance of power. The precarious equilibrium could be shifted any time. Russia was beginning to emerge as a leading power in the region, pushing westwards toward the Baltic, of course, opposed by Sweden with its territories in Finland and Courland. Denmark was also opposed to Swedish interests, especially after Hedvig, sister of Charles XII, had married Fredrik, the duke of Holstein. That was thought to threaten Danish interests.
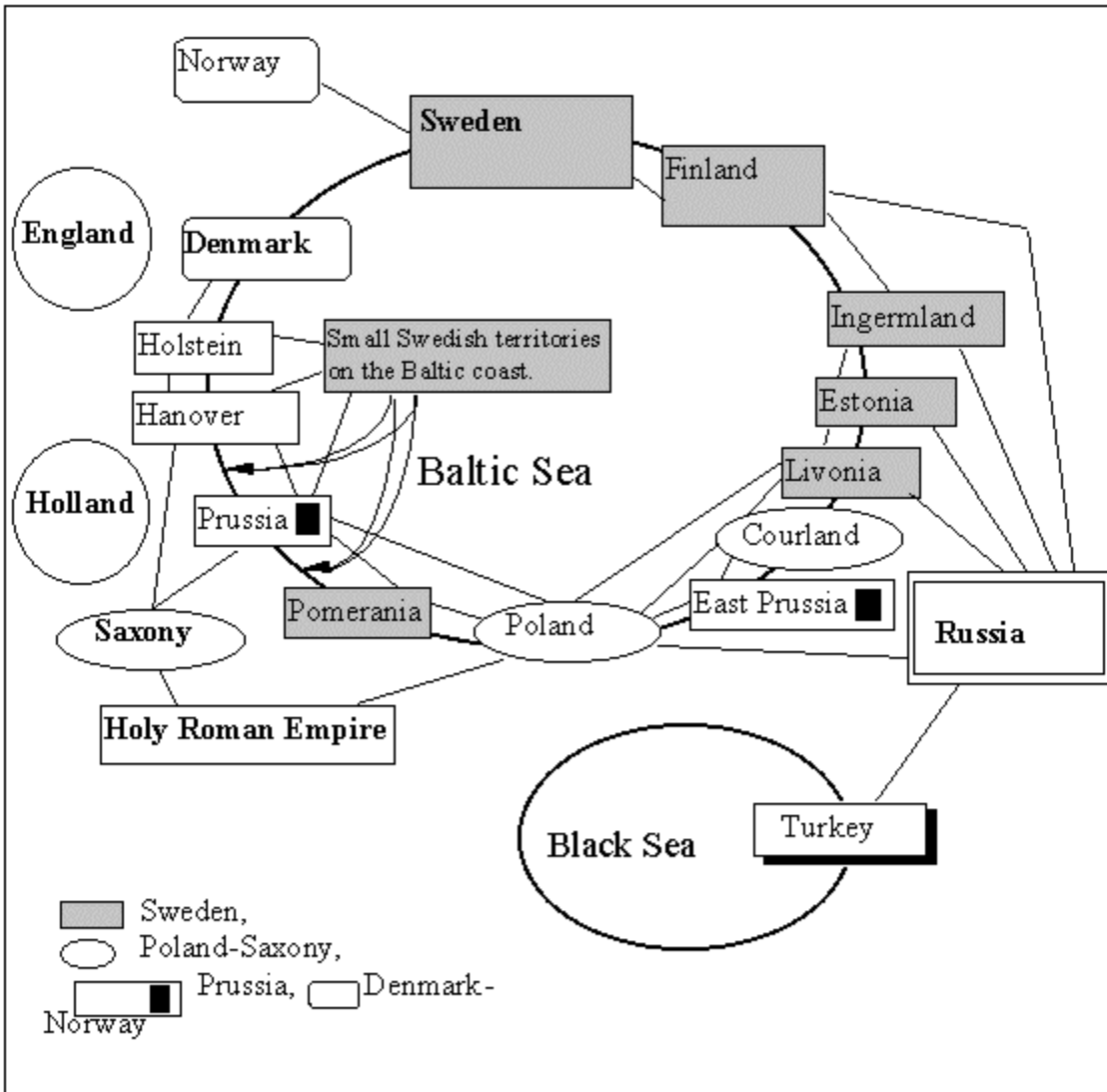
Figure 19.1. Topology of Northern Europe in 1700

Holstein cut Denmark off the rest of continental Europe. Sweden, across a narrow strait, was the second of the two close neighbors of Denmark. To complicate the picture, August II, prince of Saxony and elected king of Poland, wanted to incorporate Livonia in Poland. Prussia coveted the Swedish part of Pomerania but stayed away from alliances. Russia, with her czar obsessed with shipbuilding after years spent in Holland, was shut off the access to the Baltic Sea by Sweden and to the Black Sea by Turkey.

The war started with the Danish attack on Holstein and ended three years after Charles' death in 1718. Charles left his capital in 1700 never to come back. His marriage with Sophia Hedvig of Denmark was postponed until the end of the war, and Sophia never married. The first stage of the war was as victorious for Charles as the second one was for Peter. The elements in the form of snow and frost helped once Charles, and once Peter. Between the two stages of war, Saint Petersburg was founded as a new capital of Russia.

The Northern War is a dramatic, complex, and fascinating chapter of European history, which can be fully rendered only in a bright dynamic narrative. Here, however, we want to converge on the transition from peace to war: every war ends, but not the every war starts, and there must be some reasons for that. More specifically, we are interested how a complex situation can be dealt with in pattern terms. We have already seen that semantic network can be extremely confusing and overwhelmingly complex. We will start building it anyway because we have nothing better.

To represent this situation diagrammatically we shall create a configuration $C = \sigma(C_1, C_2, C_3)$ consisting of three sub-configurations C_1, C_2, and C_3 meaning

C_1: Sweden

C_2: Holstein-Gottorp, England-Holland, Denmark.

C_3: Russia -Poland

The list of all interested sides is incomplete, but since it would include almost entire Europe, we have to limit our entries.

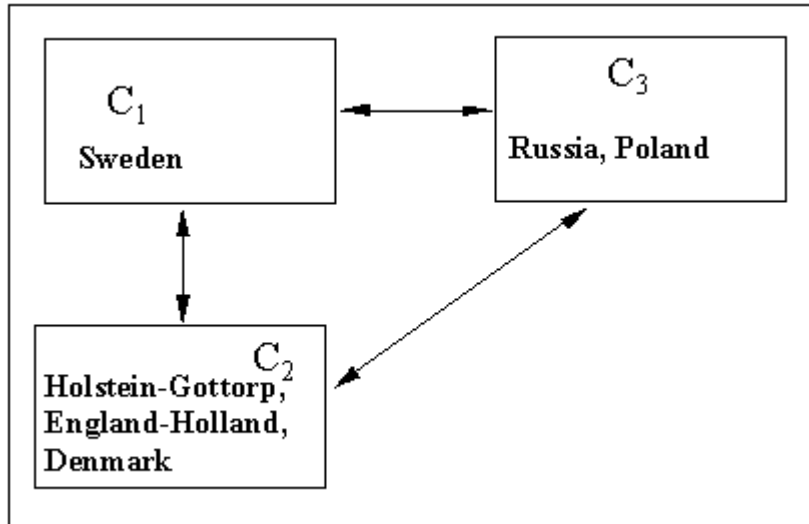The sub-configurations interact, which implies that bonds from one will be connected to bonds of another.

Figure 19.2. Snapshot of Northern Europe in 1700

The overall structure of the snapshot **C** is composed of the three large blocks shown separately in Figure 19.2. It uses generators from several subspaces:

1. Personal : Charles, Hedvig, Fredrik (of Holstein), Fredrik IV (of Denmark), Peter, August, Patkul;

2. Social: marriage, brotherhood, alliance, Sweden, Russia, Courland, Denmark, Holstein-Gottorp, England- Holland;

3. Military: navy, army;

4. Modifiers: Lutheran, Orthodox, Roman, rule, absolute, parliamentary, strong, covet. Modifiers do not exist independently.
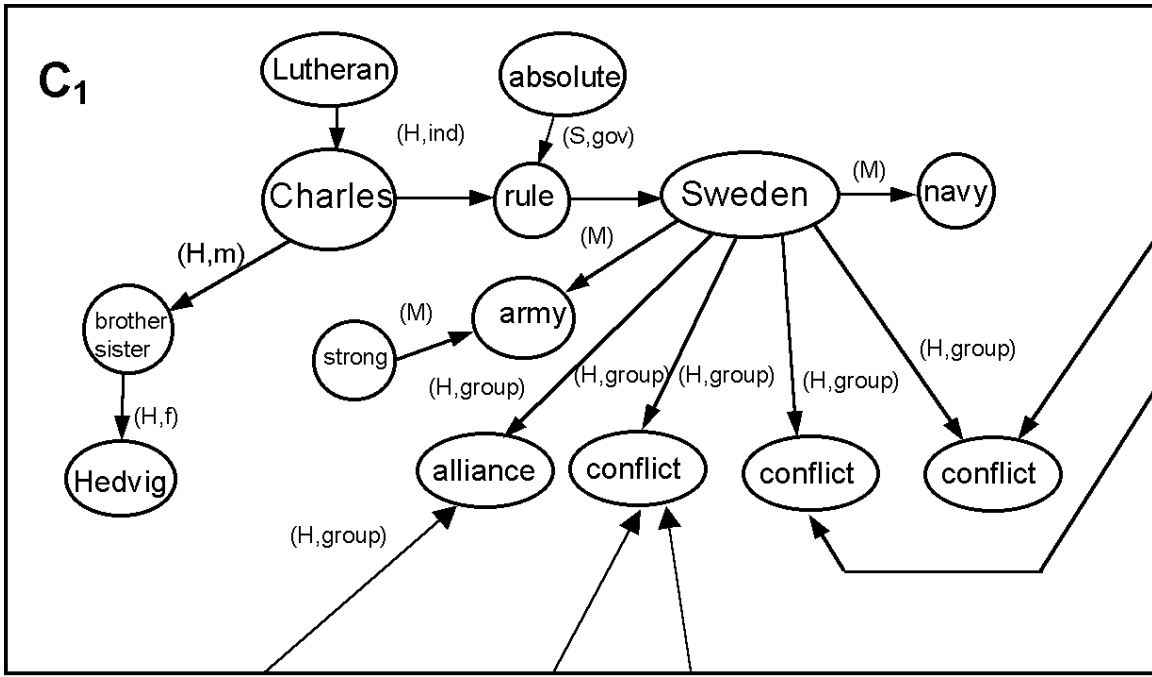
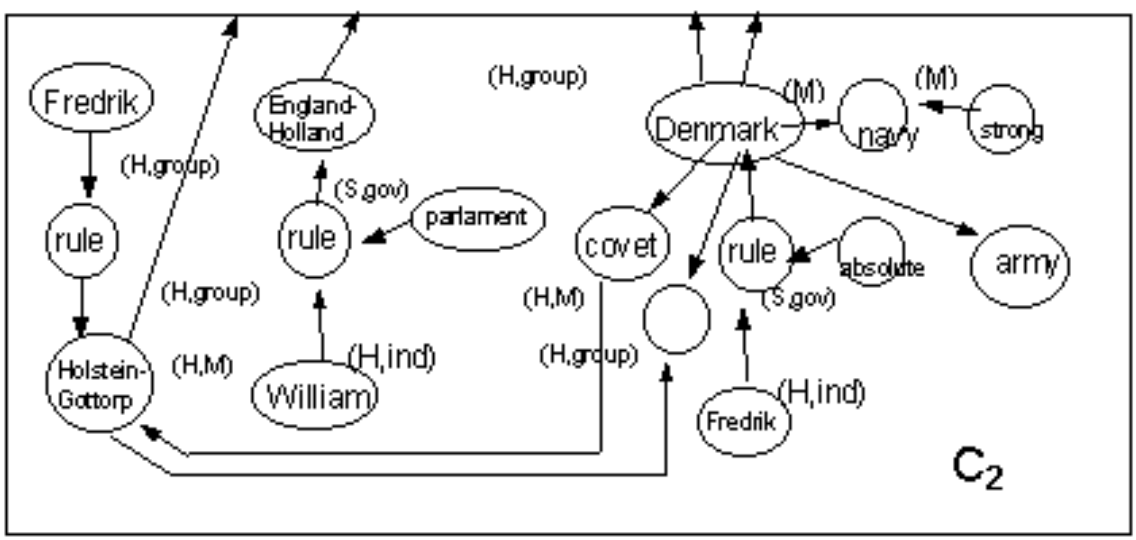**Figure 19.3. Configuration C$_1$**

Figure 19.4. Configuration C$_2$

The sub-configurations are shown in Figures 19.3, 19.4, and 19.5. The bond couple are classified as human (H) in combination with male (M), female (F), group, individual (ind), military (M), and social (S) in combination with government (gov). This is done only with the

purpose of illustrating how generators and their bonds are assigned labels that reflect the systematic relations.

Now, action! In 1699 Hedvig Sophia of Sweden, sister of Charles XII, marries Frederick IV of Holstein-Gottorp, so that Sweden and Holstein-Gottorp are linked closer, which Fredrik IV of Denmark perceives as a threat. This transformation adds an additional generator of marriage, as shown in Figure 19.7.
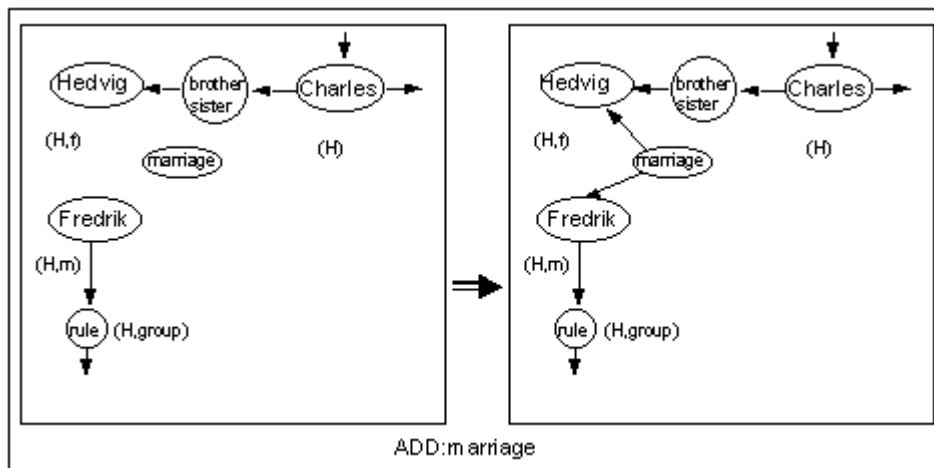
Figure 19.7. Transformation ADD

Combining $C_1, C_2,$ and C_3 we show the total snapshot of the situation 1700, *as seen by some historian*, in Figure 19.6. We can see the new bond couple of marriage in the left part of the picture. The strained relations between Denmark and Sweden are shown by the double line.

Figure 19.7 repeats Figure 19.6, shelling off the complexity and leaving out everything that does not take part in the ongoing change and adding the direction of the first attack.

Figure 19.6. Detailed view of Northern Europe in 1700

Figure 19.7. The frontlines of the conflict

Johan Patkul turns up at the court of Augustus of Saxony. He initiates what in our time could be called shuttle diplomacy, representing interests of Livonia. Sweden under Charles XI started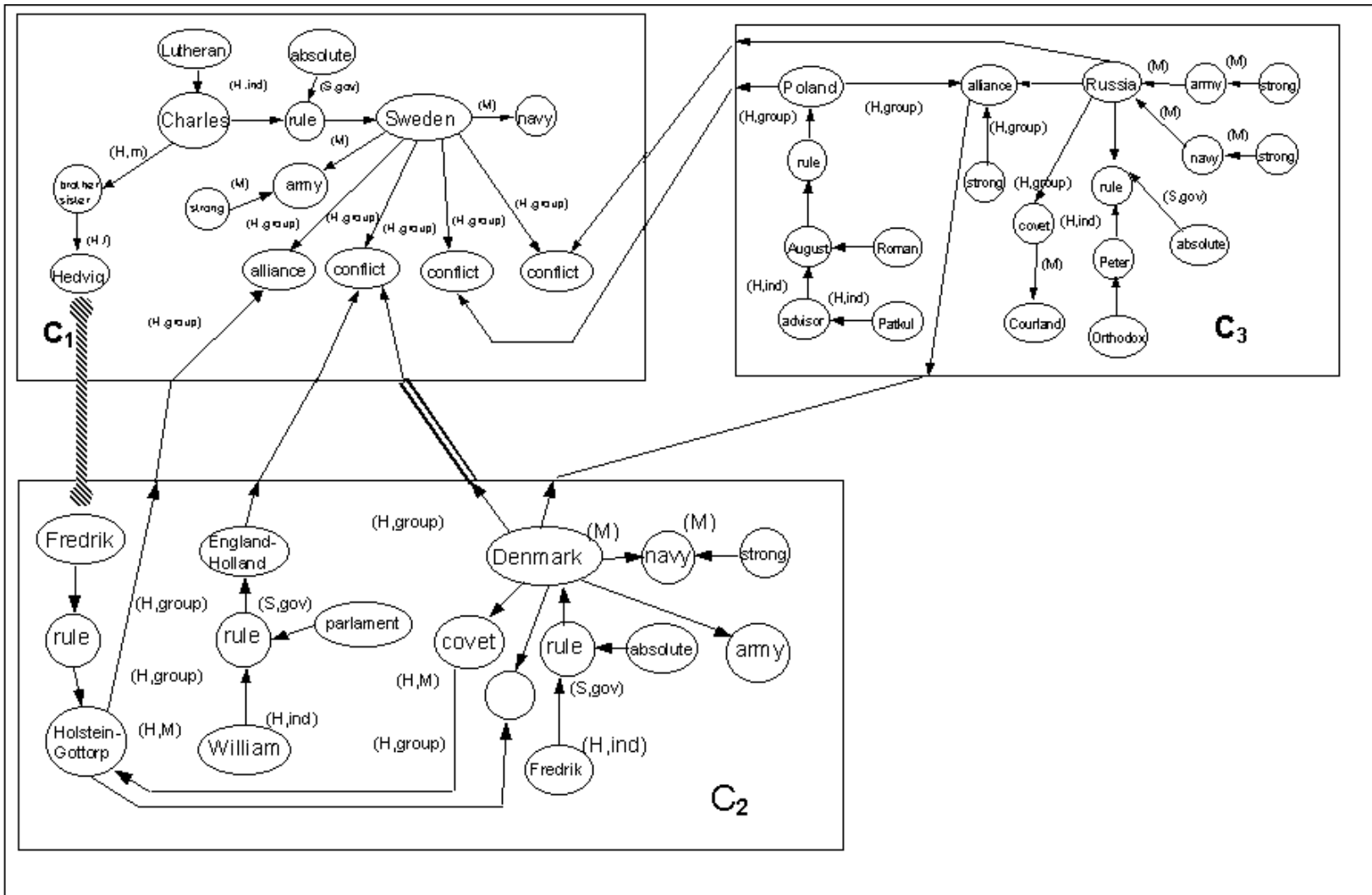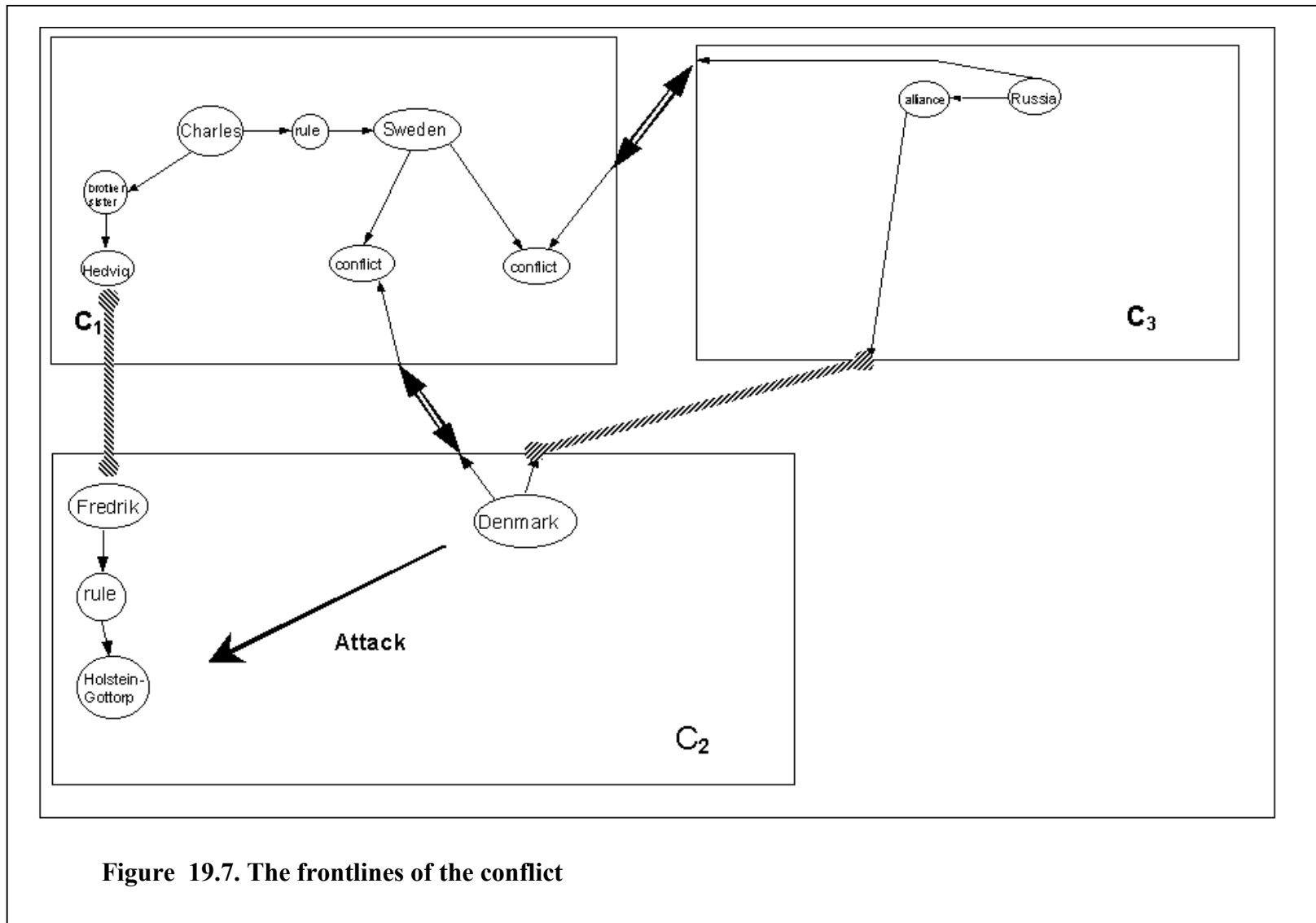 there confiscating the land of nobility. Patkul tries to build an anti-Swedish alliance including Saxony-Poland, Denmark, and Russia. In 1702, it would become Peter's secret advisor, then go back to Augustus who would betray him and give up to Charles XII.
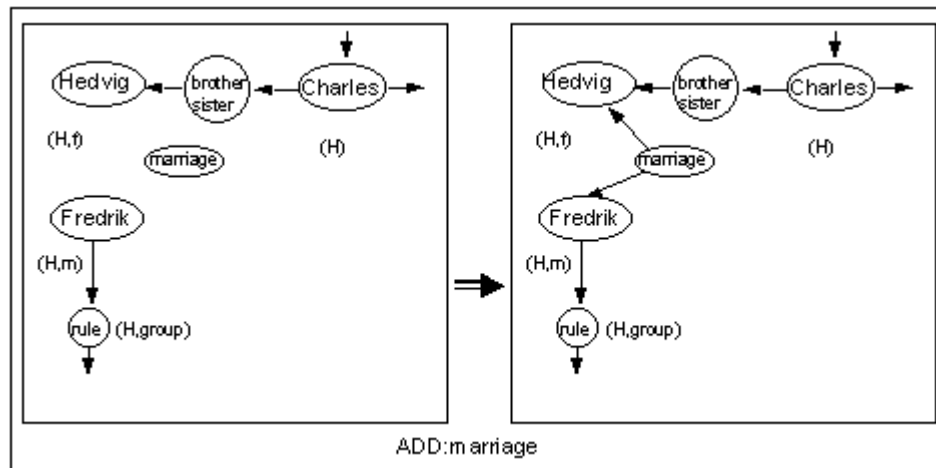
Figure 19.8. Transformation ADD

Frederik of Denmark is allied with Peter and August in a powerful alliance; they agree upon war against the seventeen year old Charles who has no allies except tiny Holstein. England was interested in the peace in the Baltics and opposed Sweden in the beginning of the war. The personal decision, shown as the transformation ADD in Figure 19.8, leads to the war situation in Figure 19.9.

The state of conflict of interests, true or imaginary, turns into war when Augustus invades Livonia and Fredrik of Denmark invades Holstein. The whole change from the upper to the lower part of Figure 19.9 looks minimal at the first glance because the connector graph remains the same.

As often happens, it is the distorted perception of the enemy and self-perception that most often contribute to violent conflicts.

This view of the event sees Charles as the young hero with no aggressive intent, treacherously attacked by his rapacious neighbors. The patterns generalizing the above configurations are common among the nationalistic historians. It would be of interest to compare them with other doctrines for similar events, to see what differences would be needed for those representations in terms of generators and transformations. Thus, the Russians saw Sweden not so much as a sworn enemy but more as an obstacle on the way toward the Baltic. Non-nationalistic historians are also split on the subject. R.M.Hatton, who himself emphasized the peacefulness of Charles, noted that for the English public the picture of Charles consisted of two different Figures, "a harsh, cruel, and war-loving tyrant," and a virtuous though unwise warrior-king, mostly due to his biography written by Voltaire (Hatton, 1968).

The bulky configurations represent only a small part of all information about the disposition in Northern Europe in 1700. As we anticipated, however, the changes occur only in a small part of generators and bond couples.

This general property of the evolution of complex systems—the locality of change, first noticed by Saussure, greatly simplifies the picture. By the same token, the principle, which seems so self-evident, allows chemists to anticipate behavior of very complex molecules. The opposite approach to history (Marx, Spengler, Toynbee and others) amounts to search for some general laws specific to history.

In our case the change is expressed by operations ADD (marriage) and MODIFY (conflict into war). Next time we can simply **omit the parts of the configurations that do not change.** Paraphrasing Rudolf Virchow, who formulated the basic postulate of biology as "every

cell comes only from another cell," we can say that every change comes from another change, which in our days is called the domino effect.
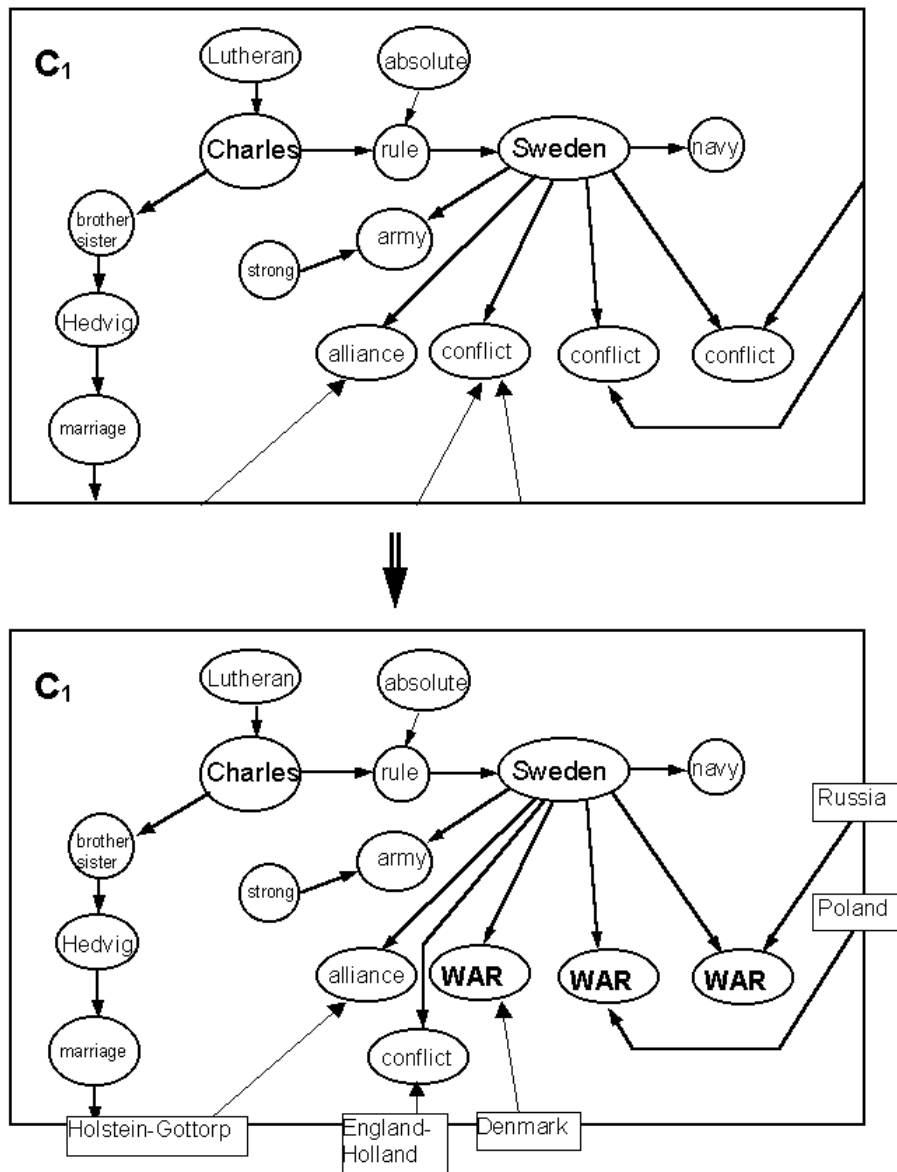

Figure 19.9. The war begins

The question remains, however, why some wars happen and some not. One way to explain it is to take sides, attribute ill intent to one of the sides, and call it evil. As we will see, it

is still a common way to explain the origin of WW2, hardly objectionable, but also hardly scientific.

Another way—we cannot be serious about it unless we give full statistics and a complete reductionist explanation—is to note the close blood relations between the monarchs of Denmark and Sweden, which usually spells trouble. In 1675 Charles XI, the father of Charles XII, married Ulrika Eleonora of Denmark. The marriage was carefully arranged to establish peace between two rival kingdoms, but a war followed next year. We can only guess what would happen if Charles XII married princess Sophia Hedvig of Denmark, as was at some time planned, and the two archenemies were tied by multiple bonds of kinship because the royal spouses would be also cousins.

Yet another way is to reduce the explanation to psychology, physiology, and particular life circumstances of the evil person. The events of September 11 rekindled a new interest in political psychology regarding the aggressive and destructive personalities.

Yet another approach is to use the concept of amplification of accidental events in the atmosphere charged with tension.

A different explanatory strategy is to regard a conflict as natural process described in structural terms. We do not claim its miraculous powers, but it is worth trying.

The Ariadne's thread seems to work. Finally, we can get out of the labyrinth of complexity, disentangle the semantic net, and look for a set of simpler blocks in intricate historical pictures.

It seems that Leo Tolstoy was right in his desire to reduce history to elementary acts.

20. Probability and energy

Looking back at the entire history of sociological ideas, we can see two approaches first formulated by the founding father of sociology Auguste Comte: static and dynamic. We can study the snapshots and lasting structures of society, but they may not reveal why and in what direction the change will follow. The occasional pilgrimage of humanities to oracles of natural sciences has not yet brought any magic solution because the questions asked were either static or dynamic.

Let us start with a different view of a conflict: not structural, but, so to say *historiophysical* or "histophysical," a term that, as we half-seriously hope, may someday take a seat between biochemistry and biophysics.

Our next model is a boxing match, Figure 20.1.

The events begin with the starting state **A** in which the boxers—fresh, neat, and vigorous—shake each other's hands.

1人

The hidden principle behind this physics is that nothing happens on its own, because if anything can happen on its own, it happens immediately. If so, everything happens at once and after that, time stops.

In chemistry, it is often the chaotic energy of heat or radiation that raises the energy of a system to the level of the *transition barrier* that separates initial and final states. The states of a system are separated from each other as valleys by mountain ridges.

> NOTE. In the physics of quantum objects, for example, radioactivity, the events seem to happen on their own and the decay of an individual atom is unpredictable. The statistics, however, reveals a rigorous law.

In fact, there are metastable states when only a slight excessive force is needed to start a transformation. A rock on the very edge of a precipice is in metastable state, and a push can send it tumbling down. The avalanche is another example of a system in a metastable state: a very small impetus, a loud sound, for example, can trigger the release of enormous energy.

The anti-nuclear activity of scientists was inspired, probably, more by a very clear realization of the universality of thermodynamics than by any moral consideration: any nuclear—and even common—explosive resides in a metastable state because very little energy is needed to release the enormous amount of energy inside.

In the example with boxing, the transformation starts not because of a chaotic heating but as a pre-determined and deliberately triggered event. But this does not change the principle and gives an extra illustration to the double identity of energy as work and heat: Mr. Work and Mr. Heat are like Dr. Jackyll and Mr. Hide. Heat is chaotic, blind, and destructive while work is creative, selective, and organized.

The two views of conflict, the structural and the thermodynamic, must be somehow combined. Our next task is to show how pattern theory performs the synthesis of the split identity.

To summarize the previous chapters, the development of a unified view of the world, since its Greek inception, has been moving like trains on parallel tracks along the thermodynamic and structural lines, with only occasional exchange of whistles. The only science where both views were integrated has been chemistry (and probably, geotectonics), too self-contained to launch any mission outside its borders.

Neither pattern theory borrows anything from chemistry, nor *vice versa,* but chemistry, as we have noted, is a good model for some ideas of pattern theory.

Chemistry somehow integrates both structure and thermodynamics in a very simple and efficient way. Our advance in pattern theory up to this page has prepared us to a very abstract way of thinking and we can now overview some chemical concepts not so much for the sake of chemistry as for the purpose of pattern illustrations.

Energy is the measure of the ability of the system to change spontaneously. The higher the energy, the more probable that the system will drop lower on the energy scale.

At normal conditions, every chemical bond is strictly positive. It can be closed with release of energy and broken with absorption of energy. The products of the break-up store the consumed energy, and, therefore, are highly unstable and inclined to get rid of it, which is possible if they recombine in the original or a new way. Chemical transformation reminds a business cycle when money is borrowed in the bank, invested, and returned with either profit or loss, without the entire loan being transferred as bags of cash. The balance—positive or negative—is much smaller than the amount of energy necessary to break a molecule into atoms

and then get it back by reassembling the molecule in a new way. Besides, the chemical reaction, like history and evolution of life and language, consists of steps that are mostly strictly local in space and follow each other one at a time.

The external energy is used to bring the chemical system into a transitional state of a higher energy, which enables the system to either roll back to the initial state or to roll over the top and fall down the other side of the hill toward the final transformed state (Figures 13.1). As soon as the system is at the foot of the hill, the energy is returned, usually. with a surplus or deficit. Since there are many molecules taking part in the chemical reaction, the whole enterprise looks even more similar to the way banks do business by keeping a smaller amount of cash for holding huge accounts in the fractional reserve system of banking.

The problem with chemistry is that in most cases it is impossible to deliver energy to an individual molecule or its selected part (it happens, however, in biochemistry and some other areas of chemistry) and, in the language of banking, open an individual molecular account. To speed up the process, the chemist simply heats the whole crowd of molecules (we can talk about a corporate account here), and because any property of the crowd always distributes along the bell curve, some of them are so excited and brimming with energy that they can rise to the transition state and overcome the invisible walls of events (Chapter 13, *History in the making*). This may happen without any heat at all.

It is not accidentally that we choose the anthropomorphic language when talking about chemistry: we want to emphasize the profound pattern unity of our knowledge of the world.

We should remind again that whether we are talking about history, mathematics, or chemistry, this book is not a good source to learn about all those intriguing sciences because we drastically simplify the subject: all we see is gray X-ray shadows.

To keep two very distant objects in focus often requires stepping back from both, and who is better equipped with the bird's eye than mathematicians and poets? The pattern message of chemistry was first noticed, not surprisingly, by the German poet Johann Wolfgang von Goethe.

The range of Goethe's interests outside literature was incredibly wide: philosophy, history, law, physics, geology, anatomy, botany, architecture, music, etc. In his youth, he studied chemistry. Goethe was a great universalist in the sense that he, like Leonardo da Vinci, could freely breath the air of both sciences and humanities.

One of the characters in his novel *Selective Affinities* thus explains a situation with two couples considering a swap of partners: "...the captain said, 'I can express this briefly in symbol language. Say that A is closely affiliated with B...think of a C that is similarly related to D; now bring both couples together: A is attracted by C, C by B...'"(Goethe, 1988).

Goethe gives the "chemical" equation right in the text:

$$
\begin{array}{ccccc}
\mathbf{A} & \mathbf{C} & & \mathbf{A} \;\text{---}\; \mathbf{C} \\
| & | & \Rightarrow & \\
\mathbf{B} & \mathbf{D} & & \mathbf{B} \;\text{---}\; \mathbf{D}
\end{array}
$$
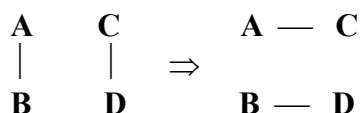
The novel was written in 1809, almost twenty years before chemists got any notion of chemical structure, but the idea of chemical elements selectively combining into complex substances according to their affinity to each other was already discussed by Goethe.

In what appears today as the language of chemistry, Goethe used the term affinity: the *affinity between A and C is greater than that between A and B* and this leads to the change in the diagram. But this assertion is also reminiscent of the language of statistical mechanics, a part of mathematical physics related to thermodynamics.

The strength of a chemical bond is measured in terms of energy. There is a deep relationship between energy and probability, however. A weak bond is more probable and a strong bond is less probable to break. A superhero often takes a beating in a movie, but his final defeat is certainly improbable.

So far, we have only insisted that the configurations should be meaningful (regular) but we have not said anything about how much we believe in them. Is one more likely than another? If we accept a configuration as regular, we ought to believe that it describes a situation which is at least possible in principle. That does not mean, however, that we think of it as necessarily true or even likely.

In the natural sciences we can express evaluations of likelihood through *probabilities* for which there exists a centuries old and well established theory. Although the philosophical issues in probability theory are far from being resolved to everyone's satisfaction it nevertheless serves as an indispensable tool in the everyday practice of science. When it comes to social science and humanities it is less clear what the term "likely" should mean.

Let us see how probabilities are understood and operated in the natural sciences and technology where they are fractions from 0 to 1 and can be estimated, at least in principle, by repeated observations. Say, we are interested in some event E, for example that it rains in Providence, Rhode Island on June 15. If we have access to observations of the weather for that day from several years, we just calculate the percentage of days that it rained and get some number, perhaps 17% or 0.17. Then this is an estimated probability and may have its uses when we decide on how to dress on the morning of June 15 this year. Even if this is not so great for weather prediction, the idea is clear: probabilities are *numerical* and can be measured.

We shall make a brief excursion into science and reflect on how probabilities can be used in physics, in particular statistical mechanics. Consider two particles, let us not specify what sort, just enumerate them as *i* and *j*, and let E_{ij} denote their combined energy. Of course, E_{ij} will depend upon their velocities, the distance between them as well as on other characteristics. Now, if we have a whole system of particles enumerated *i*=1,2,3...n the total energy **E** is the sum of all the $\mathbf{E_{ij}}$ or, in mathematical form,

$$E = \sum_{i,j} E\underline{ij}$$

In this notation Σ means the sum of the energies of all interactions between all pairs of particles. The energies fit the already familiar square table of binary relations, similar to graphs, with the energy values written into the cells of the table instead of 0 and 1. Here *i* means any particle and *j* means any different particle, so that by varying *i* and *j* we run through all possible pairs.

The number **n** could be enormous, and in a pint of a gas it could be of the order 10^{27}. In such a case, it would be impractical or impossible to follow every particle as it moves through the container.

The physicist is therefore forced to give up the Laplacian determinism and take recourse to a statistical mode of thought. Starting with Boltzman and Gibbs, the discipline of statistical mechanics was developed and applied to an abundance of systems. A remarkable and mysterious relation between energy and probability permeates this theory. It says that energy *E* is proportional to minus the logarithm of the probability *P*, or

$$E = -\, \mathbf{a} \log (\mathbf{P})$$

It is not necessary for us to fully understand this wonderful equation; it is enough to conclude that high probability corresponds to low energy and vice versa because of the minus sign. Hence, systems prefer to be in states of low energy since they are the likely ones.

It is important to understand, however, why the simple equation connecting energy and probability is so wonderful although it is nothing comparable in popularity with $E=mc^2$. Instead of energy, which can be in many forms and which is usually measurable only in physical systems, probability is universal and is equally applied to all systems—quantum, inanimate, alive, man-made, social, economical, and mental, if they satisfy certain conditions. Thus, opinions on an issue can be measured by a poll, and economic data are processed statistically. The conditions require a large number of entities that can be different in a certain aspect, but otherwise probability is as object-blind as any number.

We call minus energy the *affinity A* so that

$$A = -E$$

Affinity in chemistry is a somewhat archaic term. It was used to signify the ability of elements, for example, sulfur and iron, to react vigorously with each other. Later it meant the ability to form a strong bond, and today can still be found occasionally in the literature. For example, *electron affinity* is a term that has survived in chemistry and semiconductors and it means the energy released when an atom gains an electron. Speaking poetically, it is the measure of the atom's love for the electron—some atoms love it, some hate, and some are indifferent.

Probability theory is an outstanding achievement of the human mind, of awesome depth, and it must have been tempting for its early practitioners in the 18th and 19th centuries to apply it to questions outside the gambling and sciences and especially to human affairs and to create a discipline, perhaps similar to mechanics, that would explain how individuals and groups behave

in life and to predict their future course of action. Today such an expectation may seem

hopelessly naive, but why? As Sherlock Holmes said, "when you have eliminated the impossible,

whatever remains, however improbable, must be the truth."

History keeps records of many human affinities that greatly influenced the course of

events. The powerful attraction between Anthony and Cleopatra, as well as Admiral Horatio

Nelson and Lady Hamilton are among better known, but there were many others: Mary Stuart

and Lord Bothwell, the Russian Empress Catharine II and Prince Potemkin, Napoleon and Marie

Walewska. Sometimes the historical affinities were not much elective, as between King Charles

II and Nell Gwyn, for example. We refer the reader to a rich collection of such stories in a

charmingly old-fashioned book by Lyndon Orr (Orr, 1912).

Let us think of some recent affinities that are still fresh in memory but with all their

emotional overtones are already history.

To begin with, look at the configuration in Figure 20.2, the classical love triangle with

Charles, Diana and Captain Hewitt that attracted so much public attention. Note that this is also

the case of competition and it ends with the elimination of Captain Hewitt from the picture.
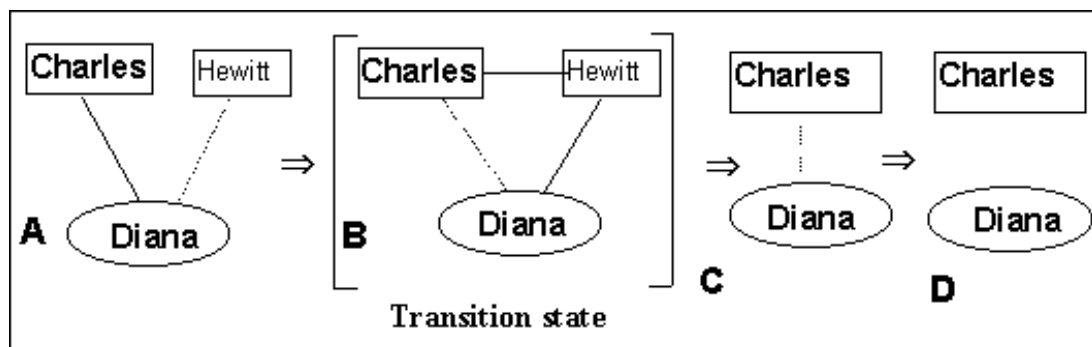
Figure 20.2. The Bermuda Triangle of royalty

Is it reasonable to attribute probabilities to it or make statements such that the transformation $A \Rightarrow C$ would take place within a year? One thing is clear: it is impossible to make repeated and independent observations of what happens, so that we cannot hope to arrive at some percentage expressing the likelihood of such a breakup. At the most, we could venture an opinion; avid readers of the tabloids know something about the participants and predict: it can't last. We would feel that the breakup would be *very likely,* while some other observer of English royalty might feel equally certain that the liaison would last the year out. Transformation $A \Rightarrow B$ tells us something about the stability of the marital bond, and the stage B cannot make it stronger, so that $C \Rightarrow D$ is almost imminent.

It would be good to quantify the strength of the bond, but how? It can be done, for example, by a public poll, and in Chapter 26 we will return to this idea.

The fact that two observers of the same event come to different conclusions is not troublesome by itself since that would actually make sense if they had access to different sources of information and hence operate within different knowledge domains. As soon as we know that the marital bond is week, we can suspect that the entire mechanism $A \Rightarrow D$ will work to its end. Yet very few were prepared for the actual tragic end, although some could have prophesied even that.

The initial stages of the pattern in Figure 20.2 repeated itself once again in 1999 at the White House in Washington, DC. We still do not know how the stressed configuration is going to behave in the future but stage D remains an option.

The fleeting pattern in a young White House intern's imagination influenced the actual dramatic events. They serve as a good illustration to Prigogine's view of small causes producing

large consequences in a system far from equilibrium and saturated with conflicting powers and human ambition.

Relationships in a family, however tangled, are not as complex as in large social systems, and this is why their breakup can be mended. With the parent-child relationship it happens every day.

The important thing is that it would not be unreasonable to say, within *one* knowledge domain, that one outcome was very probable, or not probable, or that one event was more likely than another. In such a case, we do not attach numbers, percentages, to the probabilities but make less precise statements.

The system of school grades, before multiple choices had been introduced, was an example of an approximate measuring without any scale or gauge. Instead of absolute value, percentile scores could be used to rank the objects without attaching an absolute value of something that has no objective means of measuring. Percentile scores express the position of the value among other values.

Can we subject history to an SAT test and quantify the result?

Currently, quantitative history comprises mostly research based on statistics or converting one format of data into another. For example, the data about crowding on slave ships were generated from the data about the deck area of ships of different tonnage and the number of slaves transported by ships in each category in the 1790s (Haskins, 1990). The calculations showed, to no surprise, that the area per slave was usually five to six sq. ft., much lower than the eight square feet decreed by law.

Initially, however, quantitative history meant a more daring approach.

Pitirim Sorokin, an eminent American sociologist of the first half of the twentieth century, whose path, before he escaped Russia in 1922, once had crossed with Lenin's, attempted to count significant historical events in certain area. In his *Social and Cultural Dynamics,* considering England, one of the most cool-headed nations, he listed 162 internal disturbances between 656 and 1921, or one every eight years.

Here is Sorokin's system for assigning rating points to disturbances:

1   to a disturbance of a local character in a rural county or similar limited domain.

3   to a similar disturbance in several rural counties or in a small town.

5   to a disturbance in a larger town.

10   to a disturbance in several towns of medium size or in one important city or in a small feudal region or a small province.

30   to a disturbance in a larger feudal region or province or in a part of capital city.

40   to a disturbance in several large provinces or in the whole capital city.

60   to a disturbance in the capital city and spread over several provinces.

80   to a disturbance where almost the whole country is involved.

100   to a disturbance in the entire country.

The following table by Sorokin orders the ratings according to the intensive and

		By the Amount of Violence and Effects				
		I	II	III	IV	V
	I	1	3	5	7	10
	II	3	10	15	20	30
By the	III	5	15	25	35	50
Masses	IV	7	20	35	50	70
Involved	V	10	30	50	70	100

Values given to internal disturbances. From Sorokin (1937-41).

extensive values.

Sorokin left four large volumes of similar quantifications (Sorokin, 1937-1941). This idea, however, did not find too many followers. If it did, they could endlessly argue about the numbers.

The actual purpose of Sorokin's grandiose undertaking was, apparently, to show that as long as the system of values within a society is clear and coherent, the society is in peace. The same is true about international relations. This is why he needed a quantitative measure of social and international turbulence. Extrapolating Sorokin's approach to the modern period, the advent of which he witnessed before his death in 1968, we could probably say that we had a good chance of global peace, both international and social, because the whole world seemed to embrace the uniform system of values where nothing but money matters. The criterion of Niels Bohr may be applied to such a profound conclusion: a really profound statement is the one for which its opposite is equally true. And than came September 11.

> NOTE: A remarkable personal story is as good a representation of history as painting, novel, or memoir. The clash of the runaway history with a creative person ended tragically in the case of Antoine Lavoisier. Pitirim Sorokin, an active anti-Bolshevik during the Russian Revolution, was luckier.

> > He was committed to the prison at Veliki Ustyug and fully expected to be executed any day. Instead, he was released on December 12, 1918, on direct orders from Lenin himself. A few days earlier, writing in Pravda, Lenin had announced a major change in the government's policy concerning the intelligentsia, arguing that it was important to gain the allegiance of the educated, especially those from the peasant strata who had now turned against the new regime after valiantly having fought against the Czar. The Communists should cease to persecute them, Lenin argued, and attempt to convert them into allies. It was in pursuance of that new directive that Sorokin was released and sent to Moscow. It turned out that one of his former students, now a Commissar, had pleaded with members of Lenin's cabinet who knew him well. They had agreed to talk to Lenin.

Lenin was persuaded, wrote the Pravda article, revoked Sorokin's death sentence, and ordered his release. At the end of 1918, Sorokin returned to Petrograd University and resumed his academic duties. The days of his activist involvement were over" (Coser, 1977, p. 482).

Notwithstanding sociological applications, Sorokin's idea is a helpful illustration to our qualitative mathematics where the exact numbers do not matter. What matters is that any two entries in the list have either MORE or LESS relation. In the language of mathematics, the entries in Sorokin's tables form partially ordered sets. And this is the way we will proceed: trying to formalize the more or less vague notions we have of likelihood in terms that do not attach percentages to our beliefs but allow us, at least for some events, to say that one event is more likely than another. The mathematical notion that underlies this sort of reasoning is called a *partially ordered set.* Here is its mathematical definition.

A set with elements **x, y, z...** is said to be partially ordered if for some pairs of elements, say **x** and **y**, if there is a relation denoted "≤" : **x** ≤ **y** with the reflexive property:

(I) **x** ≤ **x** for all **x**,

the transitive property

(II) if **x** ≤ **y** and **y** ≤ **z** then **x** ≤ **z**, and

(III) if **x** ≤ **y** and **y** ≤ **x**, then **x** = **y**.

In common language it means, for example, that if we have a bushel of apples, we can arrange them in the order of increasing size as we guess it from the appearance and without measuring. For some pairs, however, we may be in doubt, because "size" is somewhat subjective property. The result of our evaluation will be not a sequence of individual apples but a row of piles within which the differences are not observable. The largest piles will be in the middle, the smallest in the beginning and the end, conforming to the bell curve of natural distribution.

Returning to the configurations in Figure 20.2, we claim that, with a certain knowledge base, it may be reasonable to make at least non-numeric statements about possible developments. Now let us generalize and consider the pattern, not the particular configuration in the examples. Then it is no longer seems sensible to ask for probabilistic evaluations. Indeed, it seems presumptuous to assume that we know so much about human nature that we can rationally evaluate or compare the likelihood of different events in such great generality.

When we make a doctrine more general it also becomes thinner: the statements it allows will be less powerful. This is in our opinion self-evident although not always kept in mind. Actually, in our own endeavor we run the risk of trying to become *too* general, too all-encompassing, and we shall continue with the *caveat* that our discussion be kept as concrete as possible.

We have offered only a very brief and superficial glimpse of the way we can talk about the counterpart of the thermodynamic energy or bond strength as applied to patterns. We can summarize now the entire approach in the following recapitulation.

We have suggested that representations of knowledge be built in the following stages:

1. Create building blocks, generators, to be combined into compound structures (configurations).

2. Introduce groups of similarity transformations that modify generators.

3. Equip generators with bonds in order that rules can be stated allowing some generators to be glued together.

4. Define a bond relation that will rule whether a combination is locally regular or not.

5. Express the over all logical architecture, the global regularity, of the doctrine by a family of graphs, a connection type.

6. Form the configuration space of all configurations that are both locally and globally regular.

7. Applying the similarity transformations to the configuration space, induce patterns to express the constants of the doctrine.

8. Examine also transformations that destroy regularity: the heteromorphic ones.

9. Impose probabilities on configurations and patterns.

The last point means that we differentiate between more strong and less strong bonds or, to put it differently, between different degrees of affinity and repulsion.

The remaining problem is how to reflect the dramatic interaction of what people have in their **minds** with what they historically have been **doing** to each other, from self-sacrifice to royal and presidential scandals to wiping millions of people from the face of the earth.

To approach this difficult subject of relation between human ideas and actions in a historical aspect, we need to pay more attention to the structure of energy itself.

21. Ideas and actions.

History is as much about actions as about thoughts that prompted people to act. Of course, sometimes we are irrational, act first, think afterwards, have second thoughts, or meditate and not act at all, but in history of civilizations, simple ideas, such as, for example, that there is only one God, the monarch can rule with the consent of people, all people are not only born equal but *are* equal, or that the pursuit of individual happiness is the ultimate meaning of life, brought about major social transformations.

A full range of views has been expressed in the literature on the relation between the hidden thoughts of the leaders and masses and their actions.

Do people act of their self-interest and instinctive urges or out of idealistic motivation and sense of duty? Are their actions simply the consequences of conditions of life and actions of other people? How do the thoughts of individuals influence their actions and how do the individual actions push ahead the overall social change? To review all the questions and answers

would mean to review the entire philosophy and theories of history, sociology, social psychology, and literature, starting with *Hamlet*. We refer the reader to some books (Lloyd, 1986; Renier, 1965; Timasheff, 1965; Wilson 1978, Ritzer, 1983).

Attempting to throw a pattern bridge over the vast span between history and chemistry, we found a natural island amidst the river, which we can use for a pier: social psychology.
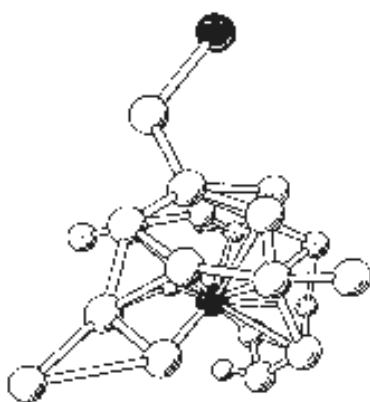
Figure 21.1. Cognitions bound together in a complex latticework of social communication. From Newcomb (1965)

The parallel between social sciences and chemistry is based on the somewhat superficial similarity between large ensembles of interacting but otherwise free molecules and large ensembles of interacting but otherwise *partially* free individuals. It is the small social group that resemble a molecule most. Chemistry turns to atoms for reductionist explanation and sociology turns to psychology for the same reason.

To illustrate the "chemical" mindset of social psychologists, we reproduce an illustration from an older book on social psychology in Figure 21.1 (Newcomb, 1965, Figure 5.2). This is not a social structure but a network of *cognitions*, i.e., such mental units as idea, belief, opinion, knowledge, conviction, etc.

The authors comment the figure:

> ...we proposed that large amounts of information cannot be retained in storage unless organized in some way, and we suggested a number of rules of psychological belongingness which govern the broad outlines of such organization. We also suggested that the more information held about a complex or inclusive object, the more numerous and varied are the cross-referencing ties that organize it with respect to other cognitions. These ties might be thought of as something like those that link balls in lattices, in models of the arrangement of atoms in complex molecules. The

element near the middle (black), with its multiple ties to other elements, is far more centrally embedded in the latticework than the gray element at the top of the figure (Newcomb. 1965, p. 119).

The classical example is a smoker who is considering to quit. Two opposite ideas are struggling in his or her mind like a demon and an angel or "to be or not to be": "to smoke is good because it feels good" and "to smoke is bad because it is harmful." The victim of the *cognitive dissonance* (Festinger, 1962) is being torn apart. He may quit for a week and then resume smoking for a couple of day, and so keep swinging between the two states, each of them giving only a short comfort.

Theory of cognitive resonance exemplifies a whole class of relatively old structural theories in linguistics, social psychology and anthropology with the same general premise: simple structures, usually, triangles, can be either stable or unstable depending on the distribution of positive and negative bonds in them. They are known as theories of structural balance (Claude Lévi-Strauss, Peter Abell, Fritz Heider, Theodore Newcomb and others). For example, the relation of liking between a student, a teacher, and a certain object, fits one of eight configurations, two of which are shown in figure 21.2.

It may not be quite clear why a student who likes the teacher, but not the object of liking by the teacher, should feel any discomfort or why the student who dislikes both feels much better. The one-way relation of liking is not what we regard as positive bond couple but simply a link in a semantic network. The reason why we mention this class of theories is because in our language they all imply the varying *stability of a configuration* as function of the bond couples. This frame of mind is both very chemical and fully "patternalistic."

We find in social psychology counterparts of many basic chemical ideas. Chemistry appears to lack negative bonds, however. To be precise, there are negative and neutral bonds in

chemistry. Chemists call them antibonding and non-bonding molecular orbitals), but atoms without a positive bond together can be immediately separated by molecular chaos. It is different with humans: four walls and financial dependence can keep a dysfunctional couple together.

> Consistency theories derive their name from the end states that individuals are presumably seeking to attain. When one looks at the antecedents of consistencies, however, then these theories are all conflict theories. By that we must mean that all consistency theories have one basic conceptual property in common—they must invoke *at least* two elements that stand in opposition to each other. This is true of dissonance in which there are two cognitions that are obverse to each other. ... In balance theory the conflict is of a similar nature: It is in the structure of positive and negative bonds. (Lindzey, 1985, p.207).

Turning to sociology, we find a clear parallel with chemistry in Robert K. Merton's (1968) theory of *net balance* of a social system incorporating positive *functions* that keep the system together, *dysfunctions* that are counterproductive, and, most remarkably, *nonfunctions* which are irrelevant, probably, like a second spout would be in a kettle.

The state of the smoker is portrayed in Figure 21.3. He may be in three states: **S**, smoking, **D**, discomfort, and **Q**, quitting. The degree of discomfort or frustration, **F**, is plotted against **X**, which is a non-numerical axis of progressing change.
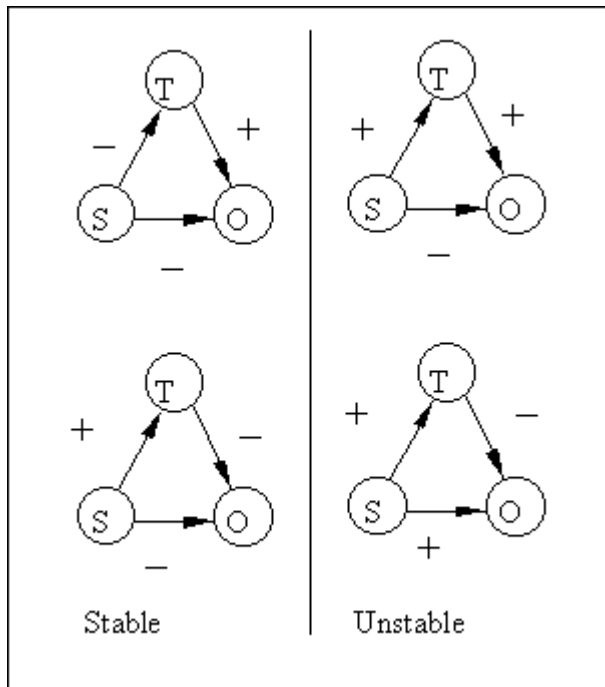
Figure 21.2. The balance mode of liking. T - teacher, S - student, O - object, + like, - dislike.

The question is, what is the probable outcome of the situation, **S** or **Q**? It depends on the relative degree of discomfort in both **S** and **Q**. If we take one thousand smokers who want to quit and actively try it, then, probably, a significant part will achieve the goal.

It would mean that for them the discomfort of **Q** is lower that that of **S**, as the diagram shows. For others **Q** is higher than **S**, and they will not be able to quit. The statistics of such attempts over the population would give us the actual heights of **S** and **Q**, quite useless in any individual case, and the statistics over the individual over time would give another estimate of **S** and **Q**, probably, also useless in the long run.

The process goes through the *transition state* of high discomfort **D**, where the two opposite ideas do not fit the same personal doctrine and are logically incompatible. In other words, they are in the state of conflict. The degree of **D** may be so high, that some non-smokers will never try to smoke and some smokers will never try to stop. If not for the intermediate state of a great discomfort **D**, the smoker would be able to quit immediately and as easily as to drop a match burning his fingers.

We recognize in the Figure 21.3 the familiar diagram of a chemical or social change
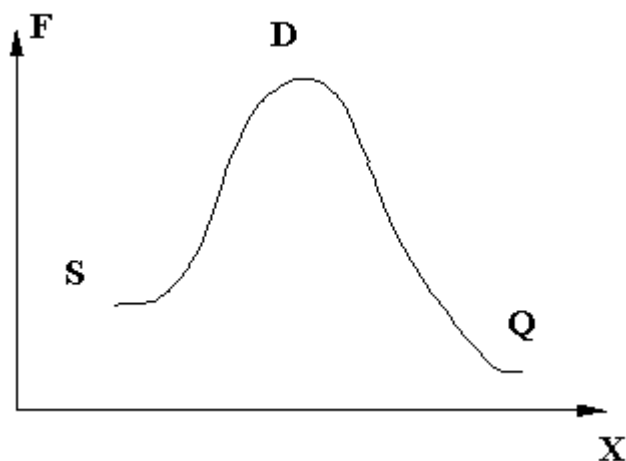
Figure 21.3. The level of frustration in the smoker's dilemma

through a transition state, compare with Figures 15.1 and 20.1. What is different this time, the curve does not reveal any observable configuration behind it: neither a molecule, nor a social system. We have the "physics" of the change but not the structure. As soon as we present thoughts as

configurations, however, the parallel with chemistry becomes very close.

Figure 21.3 may be reinterpreted in a chemical way as an intact match, **S**, and the same match burning, **Q**. Heat evolves during burning and the energy of the burned match is lower than that of the initial match, taking to account oxygen and the products of oxidation. Nevertheless, the match does not burn on its own. It must be struck, i.e., elevated to the transition state **D**. Of course, the reverse transition from the smoke and ashes to the match is impossible. The diagram does not forbid it, but it would require immense scientific and technological efforts to recreate the match, not even exactly the same, from the smoke and ashes. For many classes of chemical reactions, however, it is reversible.

As an example of social re-interpretation, **S** is the state of the British colonies in America before the revolution and **Q** is the state after their independence. Both are separated by a turbulent state of turmoil. It started with the riots in response to the Stamp Act of 1765,

economic boycott, and Boston Tea Party in response to the Tounshend Act of 1767, formation of local revolutionary Committees of Correspondence, and the formation of revolutionary Provincial Congresses. It then entered the period of bloodshed, after which the energy was released and the independence established.

It may seem now that the movement for independence had such a powerful momentum that the opposite route to the colonial state was impossible. In fact, it was not fully deterministic.

It must be realized, however, that both in Britain and in America feeling was sharply divided on the main issues; that the developing contest was not so much a struggle between colonies and motherland as a civil conflict within the colonies and also within Great Britain (Nevins, 1986, p. 70).

The similarity of the mind of the undecided Americans with the torments of a smoker is obvious. This time the pattern transformation (compare to Figure 3.5), but not the vacillations of the mind, is observable.

While the colonists lost their doubts in one generation, the history of the French people trying to quit their addiction to absolute monarchy and indulge into the newly found fascination with republic is remarkably similar to the smoker's behavior. It went through many swings.

Another example is the long traditional split between the pro-western and pro-Slavic (anti-western) gravitations of Russia, which can be followed from Catherine the Great to the present Russian Duma.

Chemists would be happy if they knew as many details of a transition state as historians know about the Boston Tea Party. Figure 15.1 gives some idea how a simple transition state may look in chemistry. Instead of solid lines chemists use broken ones to show that the bonds in the

transition state are different from those in stable states. In pattern terms, if chemical

configurations are regular in stable state, they become irregular in the transition state.
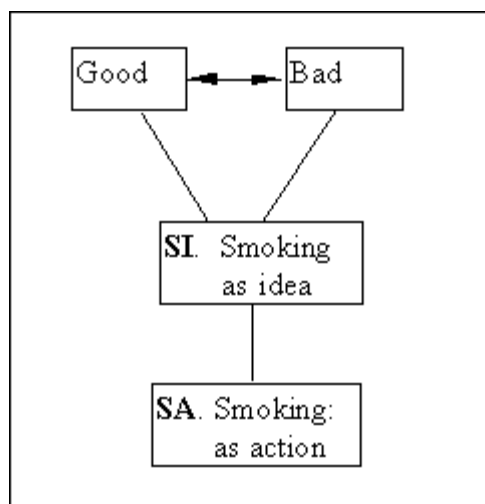
Figure 21.4. Power struggle in the mind

The transition state in chemistry is short-living—fractions of a millisecond. Nevertheless, chemists can in many cases draw a rough sketch of its configuration, which is very different from the state of a chemical quietly sitting in a jar on a lab shelf.

It is difficult to calculate the energy of the transition state in chemistry, but some tricks help chemists to compare a pair of possible transition states for the same reaction and predict which one is more probable.

The smoker's dilemma fits the pattern of power struggle or competition, Figure 21.4. We can see here a typical conflict, compare with Figure 20.21. While GOOD and BAD are ideas nowhere to be found in a physical form, SMOKING is both idea and behavior. The situation is somewhat similar to that of a joke, see end of Chapter 7 and Figure 7.3. While the struggle with the pun is resolved with laughter, the predicament of a smoker or a split nation is by no means a joke.

In pattern terms, cognitive dissonance means a presence of strong negative bonds in the unobservable transition configuration. It is the hidden process of *thinking* that lies between the two observable actions. Yet we, like chemists, can speculate on what people thought before acting.
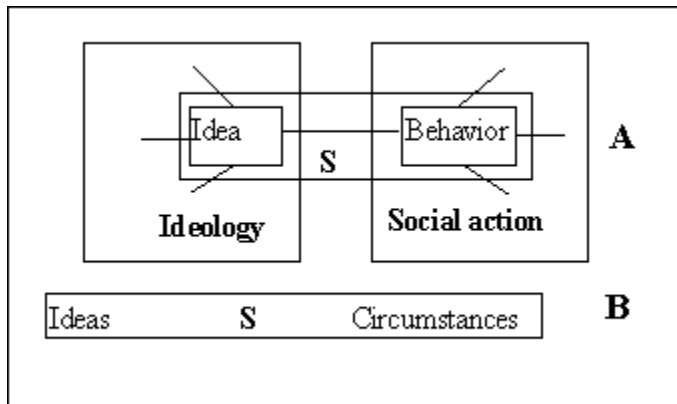
Figure 21.5. Thoughts and actions (A). The Renier stick (B) . S is a connecting subconfiguration of A.

The concept of the transition state is probably valid only for an individual decision. We can assume that it is close to the true transition state when the historical event is triggered by personal decisions and not a whole cluster of external and partially accidental circumstances. This kind of mental transition state is typical for wars and reforms, while the latter, more complex, protracted, and largely observable, is typical for revolutions. The mood of the crowd or legislative assembly, however, can also change dramatically through a transition state initiated by an eloquent speech or a charismatic act.

Idea influences behavior and *vice versa,* often in very roundabout ways. Only psychologists know how it happens, but the historians are well aware of the result.

> Ideas and circumstances are the two ends of a stick. There is no question of holding the stick by the wrong end; whichever way we seize it, we are in the position of the two ends and of the element that joins them (Renier, 1965, p. 208).

> It was Emile Durkheim's central insight to see that concepts are *binding,* and that it was this which really constituted the original unwritten social contract, the distinguishing mark of human sociability (Gellner, 1988, p. 56).

It will do for us to establish a link between ideas and behavior in a most general way, see Figure 21.5A, which can be regarded as the sketch of the Renier stick, Figure 21.5B. If here is a connection, we can regard it as a subconfiguration (**S**) that has bonds with both worlds of ideas

and actions and not to fret over the inner mechanisms. We would like to emphasize once again the remarkable property of mathematics: it is indifferent not only to human system of values, colors, and signs, but also to the classification of the world in terms of material, living, mental, and other objects. The abstract way we define generators, bond couples, and configurations gives us the uniquely mathematical breadth of scope and we can stand one leg on the each edge of the divide between matter and mind, remembering Spinoza's:

> The order and connection of ideas is the same as the order and connection of things   (Spinoza, *Ethics,* Part 2, Proposition 7).

If our ancestors believed that similar attracted similar, there could be something to it.

The next question we want to pose is the key to the problem of interaction between thought and action from the pattern point of view. We have nothing to say about its psychological or physiological mechanism and we in no way encroach on the territories of hard sciences.

We start from afar with the question: how to make links between generators stronger?

The simple answer is: to add more bonds. One reed is easy to break, while a bunch of them can be strong enough to build a raft and travel over the ocean.

The reason that protein molecules take complicated shapes and strands of DNA coil into a double helix is a multitude of so-called hydrogen bonds, each of them very weak if taken alone (about 20 times weaker than a typical chemical bond).

Among historical examples, mediation of an international dispute is good for strengthening the ties between the sides because it adds another tie. Conversely, an instigation of

a conflict by a third side weakens the link. This last pattern underlies the plot of *Othello* by Shakespeare.
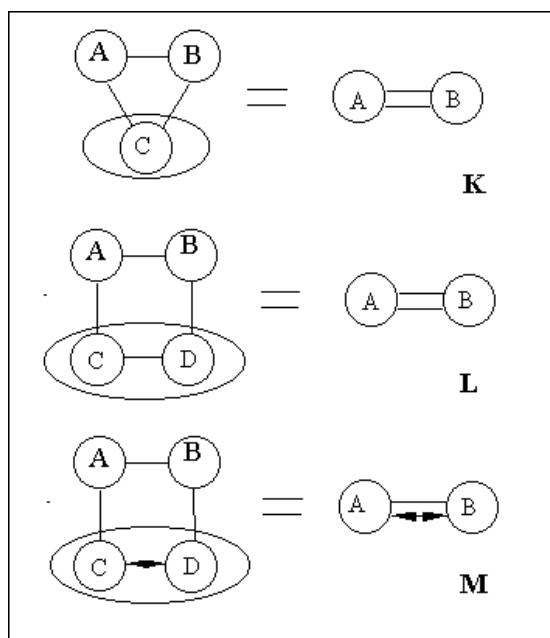
Figure 21.6. Equivalency of a subconfiguration (ellipse) and bond couple

This returns us to the magic of the triangular pattern. We postulate that a stable generator connecting both **A** and **B**, Figure 21.6K, makes the existing bond couple **A**—**B** stronger because a subconfiguration with two bonds can be regarded as an equivalent of a bond couple with a different, "double" type of bond. Two generators, **C** and **D**, connected as in Figure 21.5L are another example. If they are connected with a strongly negative bond couple, the overall effect can also be decreased affinity or even repulsion, Figure 21.5M. All this could be interpreted in terms of probability as well as energy. Configuration **M**, in other words, has internal stress, it is not too probable, and its energy is high.

Next, we want to compare this picture to something very much alike in chemistry. We have to emphasize, however, that we do not derive our vision of history either from chemistry or from mathematics. If both history and chemistry look similar as points and lines, it is because we illuminate them with the same light of pattern theory. Thus, both cucumbers and oranges are red in the red light or blue in the blue light and all the cats are gray at night.

The phenomenon to consider is catalysis, Figure 21.7, which we first ran into while discussing the Tolstoy's metaphor of fermentation.

Figure 21.7. Catalysis

Catalysis is a sequence of steps in which a catalyst binds to both **A** and **B.** This may increase the probability of bond **A—B** from almost zero to some decent value. After the bond has been formed, the catalyst can disengage and be available for another pair **A** and **B**. Its role can be compared with a clergyman who performs the marriage ritual on many couples.

A chemist may not notice a contradiction in the previous paragraph because it is visible only in the pattern light. If **A** and **B** are capable of forming a regular positive bond, it means that the probability of the bond is already high and it can hardly be increased by the catalyst. For the same token, a couple who wants to marry will do it anyway even without the religious ritual. How can anything increase this probability?

The contradiction is real. It is based on the properties of physical energy, which follows from the properties of the physical space very distinct from the "historical" space.

If the probabilities of independent events **K** and **L** are **P(K)** and **P(L)**, the probability of simultaneous events **K** and **L** is **P(KL) = P(K)*P(L)**. The probability of a chemical union between **A** and **B** in Figure 21.7 is a result of two independent events. Chemical particles can form connection only if they are at a close enough distance **D** (i.e., can collide) and are oriented toward each other in a favorable for connection way. Suppose, the probability of their *collision* is **P(C)**. Suppose, the probability of the actual *bonding* is this state is **P(B)**. The probability **P(R)** of

both events resulting in the chemical reaction is $P(R)=P(C)*P(B)$. The catalyst holds the particles together at a distance close enough to form the connection and at a favorable orientation and so increases the overall probability of the bonding. This is a loose interpretation of catalysis in terms of probabilities. More precisely, in terms of energy, the transition state, which is the complex of the catalyst with both **A** and **B,** has a lower energy than the transition state in the absence of the catalyst. Obviously, a catalyst that contributes a negative bond increases the transition barrier and is called inhibitor.

In the world of generators, we cannot draw too close parallels with the physical world because the abstract configuration space has no metrics and no physics. All we can say about positive bonds is that the bonded state has a lower energy (i.e., higher affinity and probability) than the non-bonded one. The configuration of disconnected **A**, **B**, and **Catalyst**, therefore, has a higher energy than **A-Catalyst-B**, and the final triangle is even more stable.

The question is how **C** can get out of the picture after it has done its job The chemical explanation involves the concept of equilibrium. In most historical cases, it simply fades away due to the non-conservative properties of the pattern world, becomes irrelevant, is forgotten, or is overridden by a new, more powerful catalyst. While matter and energy are always preserved, information in general is not.

There is yet another important difference between the physical and pattern world.

In chemical events, the rate of the transformation from **S** to **Q** (Figure 21.3) depends on the height of the barrier **D**, while its final result—equilibrium—depends on the difference between energies **S** and **Q**. If **Q** were much above **S**, then there would be no stimulus to quit smoking, and if the difference were negligible, there would be no discomfort in making a choice.

The more we analyze the physical model, the more artificial it seems for history. The reason of that is that we consider the transformation **S**⇒**Q** and **Q**⇒**S** following the same transition state. This is almost always true in chemistry, but never true in life and society where all the processes are irreversible in the sense that the return to the preceding state is impossible. Even if it seems that history makes a step back, the transition pathways for direct and reverse transformation are usually different. The counterrevolution is never the videotape of the revolution run backwards.

The best source for explanation of the difference between classical and non-equilibrium thermodynamics, physical world and the world of life, can be found in books by Ilya Prigogine. We cannot give it too much space here.

Let us go back to history. The almost millennium old monarchy in France was overthrown by the bloody **revolution** of 1789-1799. Louis XVI was beheaded. Napoleon Bonaparte simply **proclaimed** himself an emperor in 1804, and the new monarchy was approved by **popular vote,** and not by another revolution or counterrevolution. Monarchy was restored by the allies in 1814 after the **military defeat** of Napoleon. Louis XVIII, a brother of the executed king, was theoretically a monarch as absolute as Louis XVI, but in fact, major accomplishments of both the revolution and Napoleon were preserved. The new **revolution** of 1848, again, through the bloodshed, overthrew Louis-Philippe, but the **popular vote** elected Napoleon's nephew who in 1851, through a bloody **coup d'état** proclaimed himself emperor. In 1870, after the **insurrection** in the besieged by the Germans Paris, in view of a **military defeat**, the provisional **republic** was restored. A **civil war** of unprecedented cruelty broke out and a new republic was

established in the atmosphere of terror.
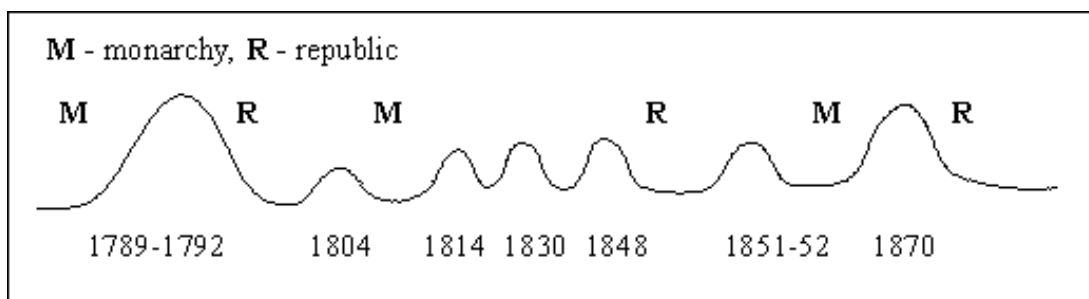
Figure 21.8. The historical roller coaster of France

The 100 year long roller coaster of French history is shown in Figure 21.8. In history, even the step back is a step ahead.

As an easy exercise, the reader can try explaining why nothing like that has ever happened to the USA. As a more difficult one, can anything similar ever happen in the future?

We will return to the above record of swinging between monarchy and republic through the excited transition states of war and revolt in Chapter 23.

A similar roller coaster could be appropriate to characterize the ridden with inhibitors Israeli-Arab and US-Soviet relations, the swings between reaction and progress in Russian and Latin-American histories, and, arguably, the history of internal American politics.

We can see a similar sway in a different cut through American social life: from slavery to abolition to discrimination to civil rights to desegregation to affirmative action to separatism, which, by the logic of history, implies integration as the next but not the final step.

In chemistry, most reacting molecules do not reach the energy of the transition state. Among those that do, only a part rolls over it to the final state, while the rest falls back and then tries to climb back. As soon as we perceive both molecules and civilizations as structures, we see

both how much their modes of change have in common and how much they are different. Most important, we see history as a natural process based on the same foundations as the material world.
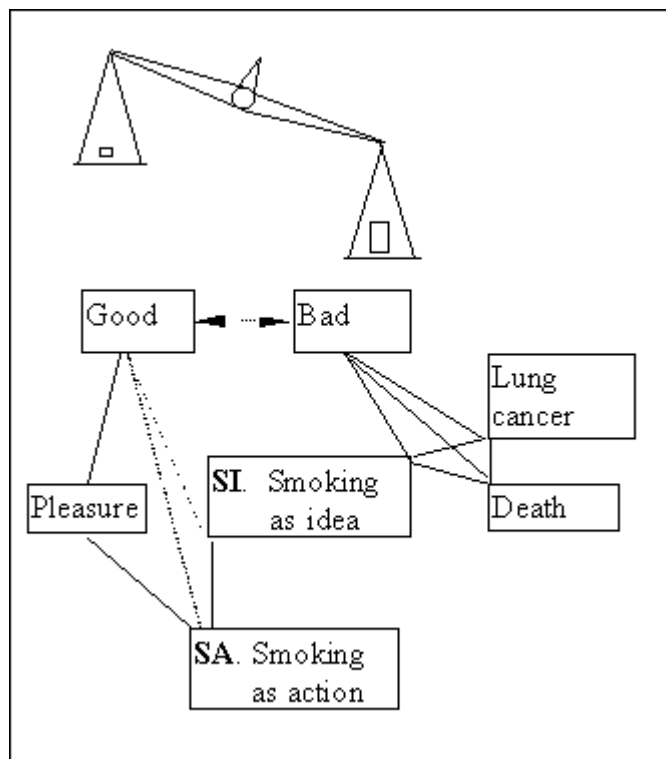
Figure 21.9. Catalysts in power struggle

Chemical events in a living cell remind the real roller coaster of an amusement park. In the biochemical version of the roller coaster, the energy of food or light brings molecules to the upper level, from which they roll down through a series of smaller bumps. On a larger scale, the turnover of matter repeats in the entire biosphere. Energy, however, cannot be fully recycled: part of it always dissipates into heat.

In history, unlike the amusement park, there is no return to the previous point, and one cannot have a second ride. It was the deep mistrust of republicanism in France, as well as the memory of the imperial glory of Napoleon, that made the road of history so bumpy for France, with the jolts reverberating throughout Europe.

The role of the catalyst in this framework is to decrease the free energy (discomfort, agitation, tumult) of the transition state, i.e., to lower the barrier between the start and finish. The chemical catalyst performs its function by selectively fixing **only one of many** possible

transitional configurations, but it does it strictly locally and it does not change the equilibrium. The social catalyst, for example, propaganda, works globally over the entire society.

Strictly speaking, chemistry and history are subject to different thermodynamics: one is reversible and the other is not. This is a cardinal distinction and we still have no satisfactory social thermodynamics. When we us the word catalyst, it is not the same as catalyst in chemistry, but *the same under a larger pattern* of "meta-catalysis":

Enhance (or inhibit) a transformation without changing itself

Obviously, all mechanical and informational tools fit this pattern, too. They play the same role in the evolution of society as enzymes (biological catalysts) do in the evolution of life.

What is reversible to a certain extent is the transformation of patterns. While the overall complex **configuration** of society can never be restored, partial social **patterns**, such as rise and decline of culture, democracy and despotism, hot war, cold war, trade war, code of law, nihilism, separatism, cooperation, etc., may be reversible. The reversibility is clearly visible in the patterns of law: Roe *vs*. Wade, affirmative action, capitalism and socialism in Russia, nationalization and privatization of industry in Europe, etc. Patterns may repeat because they are much simpler than configurations.

The reason for the frustration of the smoker is that both struggling sides—GOOD and BAD—are of an equal or close strength. Be it otherwise, an action toward the most stable state would quickly follow.

Figure 21.9 shows how additional links shift the balance in the "power struggle" between GOOD and BAD. The *information* about the mortal danger of lung cancer strengthens the bond

between the idea of smoking and its negative implications. There is also the antagonistic influence of pleasure, which comes not from any idea but from the act of smoking. This picture portrays the transition state displaying inside the smoker's mind, and the upper part of the drawing symbolizes the shift of balance that triggers the action. As soon as the balance is shifted, the frustration eases and action (or inaction) follows.

The following example illustrates the ways of decreasing the frustration of he transitional state in decision-making.

The pacifist who joins the Marines experiences dissonance. It is probably difficult for him to convince himself that either his pacifist attitude or his act of joining the Marines is unimportant. But he can think of other consonant elements in the situation. He may decide that joining the Marines is a way of defending his country and the free world. This belief is consonant with the act of joining and would educe the total amount of dissonance in the situation. If he has been offered a bonus of $10,000, special training in electronics, and a high rank, these also are good reasons for joining and are consonant with the behavior. His act is still inconsistent—dissonant—with his belief in pacifism, but the total amount of dissonance he feels is reduced. The car buyer might use this same mode of dissonance reduction. When he discovers that the car is uncomfortable, he experiences dissonance. If, however, the car handles extremely well, is economical, and attractive, these consonant elements reduce the amount of dissonance he feels. The more consonant elements in the system, the less dissonance is produced by a single dissonant element (Freedman, 1970).

What is going in somebody's mind is as much hidden from us as the transition state of a chemical reaction. We see only the stable states, and there is a barrier between the two. Figure 21.9 shows what is going on right on the top of the barrier: the hard work of calculating, comparing, and balancing the competing alternatives, resulting in lowering the barrier for the actual behavior. Jean Buridan (1300-1358), supposedly, illustrated the predicament of decision

by the example of an ass that had to choose between two equal and equidistant bundles of hay and died of hunger.

The information about the lung cancer or artery constriction plays its role and is not needed after the stable state is achieved. Like the promise of a politician, it can be easily forgotten after the election. This pattern is very general and applies to any decision making, including political decisions, effects of propaganda, change of allegiance, voting and consumption patterns, etc.

We would like to emphasize the ability of pattern approach to see how the links between generators *transcend the borders* between ideas, actions, and circumstances. This is crucial for history where the invisible acts of mind are as important as the movements of people, new institutions, and even the atmospheric extremes. While the French Revolution was neither planned nor started by a single mind, Russian revolution, Nazi aggression, and modern terrorism were strongly personalized. The decisions of the leaders are still a powerful factor of history, but they can be shifted by the catalytic effect of events that are insignificant on the historical scale.

We cannot dwell here on the relation between probability and information. We will touch only upon the definitive property of information to change the probabilities of events.

Imagine a situation when members of a family discuss plans for vacation. Trips to Yellowstone Park, Grand Canyon, Florida, and Alaska are being considered as options. Finally, they have been narrowed to just two: Yellowstone and Florida. The opinions of the parents and children are split and the debates are hot. The family has decided to toss a coin when a TV news report about the Yellowstone fire comes on. The probability of a trip to Florida suddenly changes from 1/2 to 1.

The similarity of this situation with catalysis is obvious: in both cases, *something external* changes the probability of internal events. The events can be presented as bond couples: the bond **(vacation)——(Florida)** freezes: the TV screen now works as a catalyst.

The bit of information that changed the outcome of the discussion worked only once. For a couple weeks, the media keep reporting on the fire, but there is no relevant information because information, by definition, can only be new.

NOTE: Paul Goebbels, Hitler's Minister for propaganda and national enlightenment, believed that a lie repeated many times would become truth. His thesis worked well in Nazi Germany. It seems to contradict our thesis that the repetition of a statement does not add any information. The effectiveness of the totalitarian propaganda, however, is increased by the absence of alternative and conflicting information which otherwise would shift the trust into the propaganda. This is why in the Orwellian world the sources of information and history in particular had to be constantly rewritten. In Soviet Russia, even the historical photos in archives had to be reworked after the next purge.

If we believe that the probability of the stock market rising next day is over 0.5, the information about a high-scale terrorist attack brings it down close to zero. If we expect the improvement of US-China relations within two months, the information about the bombing the Chinese Embassy in Belgrade or landing an American spy plane in China drastically decreases this probability. It all translates into the energies of the corresponding bond couples in the configuration of international relations. The catalyst can only slow down or speed up the transformation. If there are good reasons for the improvement of US-China of US-Russia relations, they will be improved sooner or later.

It is important to emphasize that the catalyst is the information that is either included in the configurations of both initial and final states or not included in either one. It acts on the transitional state. The ideas of the French *philosophes* existed before as well as after the Revolution. Taking the example of Glorious Revolution, the birth of the royal infant was a catalyst that was thrown into the historical test tube, but then was eliminated from it.

While social psychology helps us join two spans of the pattern bridge—from chemistry to human actions and further to historical transformations—it does it very differently from reductionism. We completely omit genetics, physiology, brain chemistry, geography, and economics. It does not mean that reductionism is flawed in any way. Nothing can substitute for reductionism as the hard scientific explanation. It only means that along with the theory of chaos and emergence of order there is an additional angle of view, the mathematical one, which humanities have been trying to bite anyway.

This book may or may not be such catalyst, but the authors hope it will.

In the next chapters, we will approach some large historical events and institutions as patterns.

22. Three World Wars

By WW3 we mean the world war that did not happen: the Cuban missile crisis.

A protracted modern war is in itself a transition state from the pre-war to post-war state. War can be split into episodes with transition states of their own.

On the one hand, it is natural to regard WW1 as a transition state from the self-confident pre-war Europe to the weak and disillusioned postwar one. On the other hand, the entire period from WW1 to WW2 is a transition period from the "age of innocence" to the nuclear age.

In this chapter we are interested not in the course of war but in the transition state from peace to war, similar to our experiment with the Great Northern War in Chapter 19. WW1 is a classical example of a complex and still debated maze of motives and reasons for its outbreak.

The concept of transition state as applied to history is very relativistic. We have some reasons to regard the entire history, unlike any chemical reaction, as a transition state to yet unknown future. Accordingly, we can see a transition state even in such a long process as industrial revolution or democratization of Europe, although it is more meaningful to split it into

stages, processes, and events. Here by transition state we mean anything that happens between two stable states about which we have sufficient information.

In practical terms, transition state is a quickly changing and somewhat fuzzy situation where the developments can take various directions, and the overall instability is in the air. It is essential that the transition state requires an increase of energy called stress or tension, which is difficult to measure quantitatively. In Chapter 26, *Chaos-order, heat-cold* we will discuss how it might be done. By analogy with a chemical reaction, we can regard the yet unfinished Industrial Revolution as the transition state between the steady states before and after having all mineral fuel of the earth burned up.

The First World War (1914-1918) was the conflict that signaled the beginning of a dramatic transformation of the world into a global civilization. The globalization of the world went on for the entire twentieth century in the areas of military strategy, transportation, communication, politics, ideology, economics, and culture.

We understand globalization not as unification but rather as the constant decline of the geographic factor, i.e., speaking mathematically, reduction of the topology of international relations to full graph. Speaking technically, it is the topology of the Internet where anybody can connect to anybody. It simply means that all—or almost all—nations are neighbors and have direct access to each other, regardless of distance and former spheres of influence.

War is a process running along with its own regularity, very much pre-determined by the initial conditions, like the quantity of heat and light energy obtained from a candle is determined by its size and shape. Thus, the outcome of the American Civil War was in agreement with the larger resources of the North. The fall of Napoleon and the double defeat of Germany in two

world wars were largely expected for similar reasons. The war against terrorism is mostly the

war of the West against its own liberalism and negligence: the resources of the personal

opponent are minuscule.

> NOTE. As a counterfactual thought experiment, the South could win the Civil Was by
> arranging a triangle similar to those in Figure 17.3, but the North managed to prevent that.

There is always room for chance, as in any game, for error and good luck, but in big and

protracted processes it is rarely significant. The contemporary perception of initial conditions, as

well as all subsequent developments, strongly depend on the bias of the sides, and any consensus

is possible only after the conflict is over. Contrary to popular belief, history is made by historians,

and not by people like you and we.

> NOTE: For most of the human history, the only goal of war was victory. After WW2, in a
> new kind of war with politicized ends and means, resources do not matter anymore, and
> the very notion of victory and defeat becomes ambiguous. Examples are wars of major
> powers in Vietnam, Afghanistan, Chechnya, Persian Gulf, and Serbia.

Historians usually note the spirit of doom and tension in Europe on the eve of WW1, like

heavy clouds before a thunderstorm. If we compare the accounts of contemporary and later

historians, the former are inclined to see the war as inevitable. For obvious reasons, they were

tempted to judge the sides in terms of guilt and responsibility, often influenced by the pre-

existing nationalistic penchant. The view of later historians might be influenced by new

geopolitical antagonisms.

Any dominant point of view in humanities sooner or later generates a dissident opinion.

Stuart Easton (60's) puts the blame on Russian military leaders "anxious for a war"(Easton, 1966, p. 707)

R.R. Palmer and J. Colton: "It was Russia that drew France and hence England into war in 1914, and Austria that drew in Germany. ...it is not true that Germany started the war" (Palmer, 1971, p.730).

John D. Stoessinger: "It is not true, as many historians have stated, that the Kaiser wanted war. Nor is it true, however, as his definitive biographer has said, that he succumbed to a power he had not reckoned with: the power of Fate; had it not been for that, the war would never started" (Stoessinger, 1974, p.6).

Niall Ferguson states that Britain's joining the war was "nothing less than the greatest error of modern history" (Ferguson, 1999, p. 462).

In his book *Why Nations Go To War*, John G. Stoessinger, denies the historical fatalism surrounding the perception of wars, and especially WW1. He focuses on the microscopic view of events between the historical accident, murder of the Austrian Crown Prince by a Serbian nationalist, and the formal declaration of war by its major participants. He is most interested in the transition from the state of peace to the state of war. His main theme is how self-image and the perception of the adversary push the sides to a conflict, only to be changed by new facts. He believed that the right understanding could prevent conflicts.

The gap between things "as they are" and their perception is a millennium old philosophical problem. Moreover, it is a perennial issue of historical science. One of the founding fathers of modern history Leopold von Ranke was vilified, exonerated, and praised for his formula of history as the portrayal of events "as they actually happened." It has been also an issue in mathematical logic, a study of a mathematical formalization of reasoning. We cannot

engage in discussion on either subject and we limit ourselves to the following quotation about Alfred Tarski, one of the founders of mathematical logic.

> But Tarski had shown how the notion of 'truth' as being applicable to statements that correspond to facts could be saved by speaking of both statements and facts in a metalanguage, which specifies the conditions under which statements do correspond to facts. For example, 'the statement "snow is white" corresponds to the facts if and only if snow is indeed white.' This is an expression in metalanguage (Lloyd, 1986).

This metalanguage, however, is not available to the sides of the conflict. Creating the United Nations has been an attempt to use such a political Esperanto. It can probably be developed only by a historian who is not personally involved in the conflict or its aftermath. Until the full story is known, we cannot understand it and, besides, understanding alone, as we saw on the example of the smoker, is not enough. Even if we understand that smoking is harmful and the casino always wins in the end, we may engage in smoking and gambling for the irrational reasons that Vilfredo Pareto called residues.

In terms of energy, the initial pre-war state of Europe was clearly stressed, so that the relative height of the transition barrier did not seem too high. Concerning the transition state, war has always been essential part of European history, and there was no reason to fear the next one more than any of the previous ones. The wars always ended with peace, the fields were somehow tilled, and the stock of cannon fodder somehow replenished by the European women.

The stress of the pre-war situation was a result of the preceding formation of the united and powerful Germany, united but not strong enough Italy, diminished Austria-Hungary, and weak Ottoman Turkey.

As result of a series of Balkan revolts and wars, the six centuries old Ottoman Empire receded from the peninsula, leaving an explosive patchwork of Muslims and Christians in the liberated nations set to mutual annihilation like matter and antimatter.

The last big European war was fought between France and Prussia in 1870-1871, and it ended with the formation of united Germany. Between 1870 and 1914, a dramatic transformation took place: the Industrial Revolution exploded in continental Europe and military technology came to being.

The balance of power was shifted as result of the Franco-Prussian war, 1870-1871. Germany claimed superiority in Europe and the world, which the Communist Russia claimed later, America apparently does at present, and China is a promising candidate to claim it in the future. The chain of events culminating in the transformation of Germany and her claim for dominance is fascinating in itself, but cannot be considered here.

	A	S	R	F	E	G	
A	*	-3	-2	-1	0	+3	-3 Hostile relations
S	-3	*	+3	0	0	0	-2 Suspicion
R	-2	+3	*	+2	+2	-1	-1 Cool peace
F	0	0	+2	*	+2	-2	0 No mutual interest
E	0	0	+1	+2	*	-1	+1 Cool relationship
G	+3	0	-1	-2	-1	*	+2 Necessary alliance
							+3 Strong alliance

A - Austria, S- Serbia, R - Russia, F - France, E - England, and G - Germany

Figure 22.1 . Relations between the participants of WW1

The initial cast of the drama consisted of Austria, Serbia, Germany, Russia, France, and England. Figure 22.1 presents the graph of approximate state of relationships between them, as we see it, in the spirit of Pitirim Sorokin, on the scale from -3 (hostile) to +3 (friendly).

As a response to the rise of Germany, France, England and Russia formed the Triple Alliance (*Entente*).

WW1 was the first big war after the technical revolution, with high concentration of destructive power, mobility, and momentary communications. For the first time the military technology included chemical warfare, automobiles, tanks, submarines, airplanes, and telephone on the mass scale. A layer of professionals was firmly positioned between the masses and the leaders whose white horses were reserved for parades.

The ideological arsenal included monarchy, nationalism, ambitions of world power, Slavic solidarity, all still alive and well one hundred years later, with monarchy in the form of authoritarian rule.

There was a strong network of positive bonds in Europe based on historical, cultural, and dynastic links. Italy and France were Latin sisters, as opposed to Teutons. Russia and Serbia were Slavic sisters. There were old cultural links between Russia and France, which survived the Napoleon's invasion and the Crimean war and were strengthen by financial links, while Germany and England were clinched in global rivalry.

King Charles of Rumania was Kaiser's relative, wife of Greek King Constantine was Kaiser's sister, and he himself was of a mixed Danish and Russian royal descent. Nicholas I and Kaiser Wilhelm were cousins.

Kaiser was a son of an English mother, sister of Edward VII. He and King George were cousins. Alexandra, widow of Edward VII, was from Schleswig-Holstein, annexed by Germany.

King Alfonso of Spain married a niece of Edward VII. Frederick of Denmark and King George of Greece were brothers of Edward's wife Queen Alexandra. King Haakon of Norway was her nephew. King Ferdinand of Bulgaria was a prince of the house of Saxe-Coburg-Gotha, born in Vienna. Czarina, born Alix of Hesse-Darmstadt, was German princess and Edward's other niece.

Was the WW1 a consequence of the European intermarriages and a family conflict, like among the descendants of Augustus? Barbara Tuchman collected colorful minutiae of family idiosyncrasies in her book *The Guns of August* (Tuchman, 1962).

It was not for the family matters, however, that Europe had climbed into a metastable state. The speed with which the events followed was, likely, due to the long advanced planning of the war, the clear intent, and the high impetus of imperialist expansion. As a new factor, the nationalist tension could be quickly raised by propaganda spread by the newspapers. High-speed communication via telegraph, telephone and emerging radio allowed for fast exchange of information so that events could trigger each other like chain reaction. The factor of speed, probably, played an important role in preventing the gradual dissipation of energy. Instead, the stress was released as mass hysteria and destructive power of explosives.

William II and Nicholas II exchanged telegrams after the Serbian crisis, trying to find a way to prevent the total war. With all the differences between the rational, focused, matter-of-fact William and the emotional, wimpy Nicholas, the telegrams show a clear intent to stop the thrown stone right in its flight. We quote here a part of the initial exchange in its original English language and spelling (quoted from the Web Archive of WW1) as an example of one of many

types of representation of historical events, among historical narrative, philosophical analysis,

poetry, painting, and patterns.

> Tsar to Kaiser, July 29, 1:00 A.M.
>> Peter's Court Palais, 29 July 1914
>> Sa Majesté l'Empereur
>> Neues Palais
>
> Am glad you are back. In this serious moment, I appeal to you to help me. An ignoble war has been declared to a weak country. The indignation in Russia shared fully by me is enormous. I foresee that very soon I shall be overwhelmed by the pressure forced upon me and be forced to take extreme measures which will lead to war. To try and avoid such a calamity as a European war I beg you in the name of our old friendship to do what you can to stop your allies from going too far.
>> Nicky

> Kaiser to Tsar, July 29, 6:30 P.M.
>> Berlin, 29. July 1914
>
> I received your telegram and share your wish that peace should be maintained. But as I told you in my first telegram, I cannot consider Austria's action against Servia an "ignoble" war. Austria knows by experience that Servian promises on paper are wholly unreliable. I understand its action must be judged as trending to get full guarantee that the Servian promises shall become real facts. This my reasoning is borne out by the statement of the Austrian cabinet that Austria does not want to make any territorial conquests at the expense of Servia. I therefore suggest that it would be quite possible for Russia to remain a spectator of the austro-servian conflict without involving Europe in the most horrible war she ever witnessed. ... Of course military measures on the part of Russia would be looked upon by Austria as a calamity we both wish to avoid and jeopardize my position as mediator which I readily accepted on your appeal to my friendship and my help.
>> Willy

We can only hypothesize that the fast exchange of messages created an amplification

instead of relaxation, like the positive feedback in a microphone.

In the subsequent chain of events, Austria mobilizes against Serbia, Russia supports Serbia by mobilization against Austria, and Germany supports Austria by mobilization against Russia, while Russia and France are bound by a treaty and financial ties. With every mobilization, energy goes up because a mobilized army is like a compressed spring. It all took a little over a month.

It seems that Russia entered the war exclusively for sentimental, humanitarian, and ideological reasons. At least on the surface, the reasons were similar during the NATO-Serbian war of 1999, see Figure 17.3.

The single actions, except taking lives, are almost always reversible. A destroyed bridge can be restored. It is possible to cancel a mobilization or make it limited. There was a moment when Kaiser asked Moltke to stop the movement of the troops toward France. Moltke refused to reverse 11,000 trains and direct them against Russia. General von Staab, the chief of the German Railway Division, wrote a book after the war proving that it could have been done. It was possible to reverse any action, but not the ideas in the heads of the participating leaders because the events did not wait for the "smoker's swing." Besides, it is much more difficult to reverse several actions simultaneously.

Confrontations between a statesman and a general were typical in the breaking war. The French Commander in chief Joseph Joffre refused to follow the attempt of French Premier Rene Viviani to stop the war by unilateral retreat.

In WW2, the sides were reversed: many Hitler's generals, remembering the lessons of history, resisted his pressure on different occasions. Similarly, the American defeat in Vietnam had the same imprinting effect on the subsequent US military strategy.

TIMELINE OF THE BEGINNING OF WWI:

June 28, Sarajevo. **Assasination of Franz Ferdinand**, the Austrian Crown
Prince, by a Serbian nationalist. Sarajevo was part of Austria, not Serbia.

July 5. **German Pledge of Niebelungtreue support**, i.e. unconditional obligation
of support to Austria.

July 23. **Austria's ultimatum to Serbia**.
Serbian Prince Regent Peter asks Russia for aid.
Entente asks Austria for more time to Serbia. Request of compliance from
Serbia. Edward Gray's, Britain's Foreign Secretary, suggests a
conference.

July 25. **Serbian response, rejected** in less than 30 minutes, and, probably,
misread. **Austrian mobilization** (partial). **Russian partial mobilization**.

Jul. 28. 5. **Austria declares war on Serbia**. Kaiser reads the Serbian response, is
satisfied, and attempts to restrain Austria. Bombing Belgrade.

Jul. 29. **General mobilization in Russia**. "Nicky—Willy" exchange.

Jul. 30 Kaiser receives Nicholas' message about Russina mobilization. Britain's
warning to Germany.

Jul. 31 **Germany's ultimatum to Russia**.

Aug. 1. **German mobilization. Declaration of war to Russia**.
At this point, France remains an unknown. England's position depends on
German attacking France. Kaiser's attempt to assure the neutrality of
France. General Moltke refuses to stop the trains rolling toward Belgium.

Aug. 3. **Declaration of war on France**. Retreat of France.
England declares war on Germany after the invasion of Belgium.

In contrast with the lively Willy-Nicky correspondence, we shall try now to represent some aspects of the transition to WW1 in the language of patterns.

The entire conflict flares up because of an internal stress created by accumulation of attraction and repulsion. War is made as much by friends as by enemies.

In Figure 22.2 we show, in a very simplified way, the change of the configuration starting from the pre-war situation (configuration 1) to the Russian revolution and exit from the war (configuration 6). Seen with an eye of a chemist, it could be taken for a transformation of a geopolitical molecule.

The double arrows signify negative relations, the solid and broken lines symbolize positive and neutral (or week) bonds correspondingly, and the opposing arrows mean the state of war.

 The murder in Sarajevo destabilized the situation due to its catalytic effect. We attribute it to Serbia and mark by a star, although it happened on the territory of Austria-Hungary. The shots shifted the balance of indecision toward clear division into friends and enemies. The barrier between peace and war was high because there was no strong immediate motive to start a war. An act of an individual, although directed against a prominent figure, was physically (not ethically) insignificant in itself, as compared with all the physical energy and millions of lives wasted during the subsequent war. This act, however, strengthened the negative links in the configuration of mutual perceptions. In the words of John G. Stoessinger:

> It is my conviction that, during the descent into the abyss, the perceptions of statesmen and generals were absolutely crucial. for the sake of clarity and precision, I should like to consider following dimensions of this phenomenon: (1) a leader's perception of himself; (2) his perceptions of his adversary's character; (3) his perceptions of the adversary's intentions; (4) his perceptions of the adversary's power and capabilities; and (5) a leader's capacity for empathy with his counterplayer on the other side.
>
> All the participants suffered from greater or lesser distortions of their images of themselves. They tended to see themselves honorable, virtuous, and pure and the adversary as diabolical. The leaders of Austria-Hungary probably provide the best illustration of this. Berchtold and von Hötzendorff [the foreign minister and chief of staff of Austria-Hungary] perceived their country as the bastion of European civilization. They saw an Austria-Hungary

fighting not only for its national honor but for its very existence against an enemy who had it 'by the throat." The possibility of losing prestige and of sinking to the status of a second-class power was anathema to Austrian leaders. Hence, they perceived as essential the need for a firm and fearless stand that, in their minds, would make a potential enemy back down. The fact that not only Serbia, but Russia, too, perceived the Austrian action as aggression never seriously occurred to either Berchtold or his chief of staff (Stoessinger, 1974, p. 27).

We believe this passage illustrates well what we mean by the transition state of a historical decision-making, and how its configuration can be assembled from a pitifully poor selection of generators like GOOD and BAD. We could show all that by building more detailed configurations for all the participant nations, like we did it for the Great Northern War, but we already know that decisive events are always local.

We use the names of the countries as labels of generators in our diagrams. Strictly speaking, we cannot substitute terms Germany, Austria, and Russia for the paranoid attitude of Kaiser Wilhelm to the Slavic people, German and Austrian contempt for Russia's military power, Austrian demonization of Serbs, as well as Russian despise for Austria and fear of Germany. Not accidentally, all three were authoritarian monarchies with voiceless masses. Our labels for the generators in the configuration do not identify the leaders with the people but simply reflect our distance from the detail.

Interestingly, we can see the ominous Montegu-Capulet-Romeo-Juliet rectangle in configuration 2. The conflict between Austria and Serbia might not have violated the peace for many years, but the instability of a single person made Russia and Germany active, instead of passive, enemies.
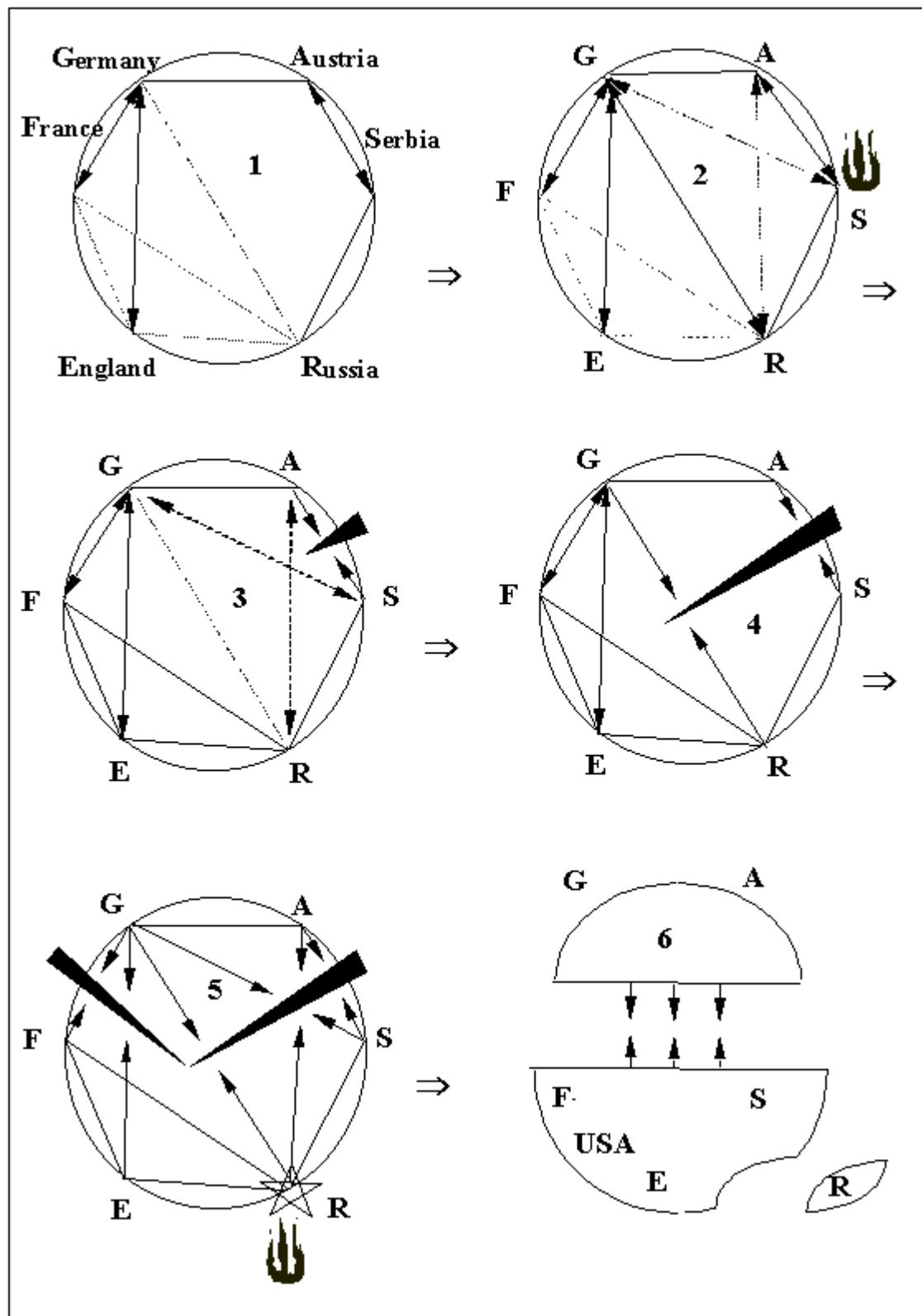
Figure 22.2. Fermentation of Europe in 1914

In our terminology, the five types of perceptions of the situation, characterized by John Stoessinger, are the components of the final state, which has not been achieved yet, and can be compared with the smoker's "smoking—good" link, in this case, "war—good." At the same time, war was still unwanted. This is the typical irregularity of the transition state reconciling opposite forces.

We associate the pre-war hysteria with the rising temperature, and, therefore, high rate of chaos and impulsive decisions made in the heat of the moment. At the same time, the invisible walls of the transition became lower because the new information—the terrorist act of a Serb—made guns even more appealing.

People make decisions in many ways, but most often they are driven by the image of themselves enjoying the result of their actions.

In configuration 2, more negative bonds are added. Next (configurations 3, 4, and 5) the neutral bonds within Entente become positive because of the activated treaties. The black wedges symbolize the big split and the state of war in the Eastern part of Europe and the following war on the western front. In configuration 6, Russia withdraws from the war as result of the October Revolution. Same year the US joined the allies. The barrier to the revolution was lowered by the war and the information about Russian defeats. The Bolsheviks lowered the transition state further by the promise of the peace and prosperity, but the Russian Revolution is a different story.

The diagram in Figure 22.2 does not reveal anything the historians cannot verbally describe. The narratives, however, are different for all conflicts on earth, while the patterns are much more general. The interpretation of the transition state as the final state perceived by the sides of the conflict is, probably, not too original either. It lies within the boundaries of social psychology, and theory of cognitive dissonance, in particular. The complete picture of the

mechanism of a historical event, however, including the concept of the transition barrier lowered or raised by a catalyst, or the initial state with tension elevated by poor harvest or military defeat, may be worth testing on a multitude of examples because it translates all narratives into the same symbolic language.

Next, we will compare WW1 with WW2 and the war that did not happen: WW3.

As compared with WW1, something was radically different about WW2.

WW2 was the first war of modern times fought over ideology, not just the spoils of war or mutual misperception. It was not the first time that abstract ideas were moving people toward war, but in earlier times it was about religion, as in the Crusades of the eleventh and twelfth centuries.

This time Russia, Germany, and America had clear-cut national brands of abstract ideas: Communism, Fascism, and Democracy. The ideas were coupled with large quantities of destructive energy.

More than any other modern war, WW2 was triggered by a single-minded decision. William L. Shirer (1960) in *The Rise and Fall of the Third Reich* lists many cases of the opposition, sometimes effective, of Hitler's generals, for whom the potential barrier on the way to war was much higher than for the Führer. Nevertheless, Germany got involved in the war on two fronts against the overwhelming power of England, France, Russia, and USA.

> In World War II, all this was very different indeed. The intent was different from the start. A total reordering of the globe was at stake from the very beginning, and the leadership on both sides recognized this (G.Weinberg, 1994, p.2).

> Hitler alone made the key decision, though those who had contributed toward the creation of that situation in so important and powerful a country as Germany, as well as those who carried it out

without hesitation, have their share of the responsibility for that decision and its terrible results for the world (G.Weinberg, 1994, p.47).

> In this regard one enters a realm yet to be seriously and reliably explored by psychohistorians, but one can no more overlook references to his personal role and age in the final war crisis of 1939 than the fact that his earlier decision to begin his first war against Czechoslovakia in 1938 was taken in early May of that year—a few days after fear of cancer had induced him to write his last will (G.Weinberg, 1994, p.29).

The phenomenon of Hitler remains an unsolved mystery. As we have said many times, our goal is not the factual truth but a possible vehicle to reach it. We are tempted to characterize Hitler's imagination as inflamed, but his pattern temperature was below freezing point.

Hitler was born in 1889 and wrote his *Mein Kampf* in 1925 as a program that he followed till his end with a remarkable rigidity and consistency. He regarded Russia as the direction of expansion, and this mental configuration finally pushed him against his own doppelganger Stalin despite all warnings of history. The pattern of the absolute dictator in this transitional period of European history was fatally complemented by the pattern of totalitarian structure of society, giving the dictator a historically unprecedented power.

Trying to reconstitute the pattern of Hitler's individual thinking, we come up with something like a triangle in Figure 22.3. The concepts of victory and defeat are linked as all polar opposites, so that the vision of the German defeat in WW1, which greatly depressed Hitler, activated the easily imaginable image of victory. If it is possible to lose the modern war (which means somebody's victory), than it is possible to win it.
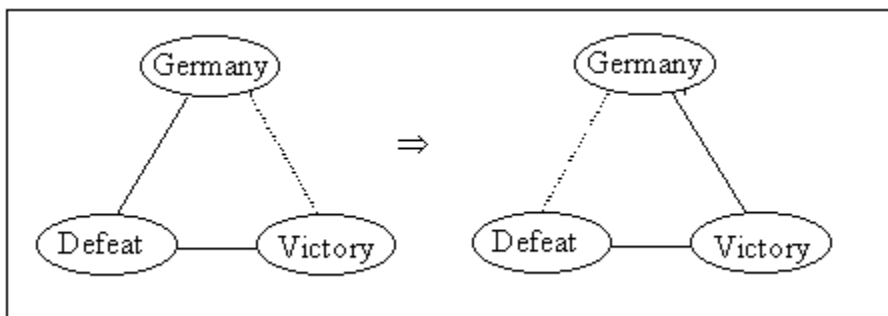
Figure 22.3. An easy switch in an inflamed imagination

The barrier between the two configurations was, probably, very low in the mind of irascible Hitler who was not burdened by education, experience, and responsibilities. The image of victory was a comfortable promise to restore the imbalance caused by the defeat in WW1.

NOTE. This pattern of rather artistic then rational approach to war seemed to be followed by some charismatic leaders of Northern Africa and Middle East, and, probably, even by the United States in the Far East after the defeat in Korea. The US, however, regarded the wars as defensive. Anyway, since perseverance is an individual virtue, it is hard to deny it to anybody.

Earlier we illustrated with Figure 17.2 the drastic transformation:

NG—(enmity)—SU ⇒ NG—(friendship)—SU

The transformation in the attitude of the Nazi leadership to war was similar:

Germany—(defeat)—war ⇒ Germany—(victory)—war

Neither the French or British, the victors of WW1, or the Bolsheviks, the victors in the bloody Civil War were interested in a new war.

Even if the pattern of the previous war ended with the defeat of Germany had a deterrent effect on the Nazi decision making, the weight was comparable on both pans of the balance: defeat asks for both caution and revenge

The transition state toward WW2 was lowered because of a particular perception of the situation by the Fascist leaders. Their perception was influenced by the historical pattern of a strong and unified national state capable of expansion and guarding its possessions. The tempting pattern of an ancient empire armed with modern weapons has been an inspiration for many dictators. Most West European nations, as well as Turkey, Iran, Iraq, Egypt, Poland, Lithuania, Russia, and Israel, had sweet historical memories of greatness (some also of humiliation) going far back in time. Similarly, the unique place of China in the world can be strongly defined by history, size, and memories of greatness and humiliation for a long time.

William L. Shirer in his analysis of Hitler's mind convincingly shows how much Hitler's ideas were shaped by the images of history, from the mythical *Niebelungenlied*, to the very real Friederich the Great (First Reich) and Bismarck (Second Reich). He also mentions the part of German philosophy that glorified power, violence, and war, but who did not glorify it throughout most of the human history?

The absolute majority of old European nations, as well as the offspring of WW1—Czechoslovakia, Poland, Hungary, new Balkan and Baltic states, and Austria—were still in the aftermath of WW1 and were weak economically and politically. Paradoxically, as it may seem from today's view, the absence of a strong will, personified by the absolute monarch, was also a contributing factor to weakness. In a sense (which means in the pattern sense), Hitler followed the pattern of Napoleon, being the only absolute monarch of an industrially strong country in the

world. If political correctness prevents us from speaking about Nazism as Hitler's revolution, let us call it counterrevolution: back to the absolute power of chieftain.

The frozen pattern of Hitler's mind was like a program frozen in ROM (Read Only Memory). The German society worked smoothly as a computer with all the bugs exterminated. There was little to vacillate about during the decision-making: the balance was rigged by a few basic subconfigurations:

Power—good, Jews—bad, Germans—superior, Communism—Marx, Marx—Jew, Russia—Communism, Russia—bad, Slavs—bad, Russians—Slavs, Poles—Slavs, etc.

We can see how the whole structure of the Nazi ideology was built from simple straight rods. The Russian Communist doctrine had the same tribal rigidity: both were cultures rather than civilizations.

In both Germany and Russia the combination of three factors created historically unique conditions for the amplification of an individual will against the background of developed industry and technology. The hardware of the national-socialist computer to run the simple software was built on a simple platform:

1. The modern media and means of communication and propaganda (their role was best analyzed by Albert Speer, the clever Nazi insider).

2. Historically new apparatus of a single and unopposed political party with military discipline, free of the election headache.

3. Apparatus of terror to enforce the totalitarian discipline.

After WW1 a peculiar authoritarian pattern was resurrected in two countries—Russia and Germany. In Orthodox Christianity, the Czar is not only the political head of state but also the head of the church and the father of the people. The title *czar* (from caesar) was often used by the Russians with the addition of *father* (*tsar-batyushka* : czar-daddy). It is a literal translation of the medieval idea of caesaropapism (caesar plus pappas, the Greek for father), i.e., combined secular and spiritual power.

Czar-father or the German *Führer* is the national leader who personifies not only power but also the right way of thinking and behavior and who actually owns the lives of his subjects. According to a witness, the wife of Paul Goebbels, Hitler's propaganda minister, planning to kill her six daughters age 3 to 12, said: "They belong to the Third Reich and to the Führer, and if these two cease to exist there can be no further place for them." Goebbels the father executed the plan by lethal injection (Shirer, 1960).

Stalin's name was, too, combined not only with "leader" but also with "father" and "teacher" by the Soviet propaganda.

NOTE: In the fin-de-siècle American politics, the President was expected by some to be not just the chief executive officer of the federal government, administrative head of the executive department of the government, and commander in chief of the armed forces of the nation, but also an infallible squeaky-clean role model, i.e. a man with qualities attributed to a moral leader of the nation, which in the democratic outdoors makes the leader a moving target on the shooting range.

Britain and France, both national states, declared the war when Hitler invaded Poland. The Nazi scenario failed from the start because the flagrant aggression mobilized resistance and made the national states strengthen their bonds in triangular patterns. An imaginable

picture of being conquered and absorbed in conjunction with patriotism and historical memories can rig the balance of decision toward resistance.

In WW2 the aggression was predictable, one-sided, but spread over time, so that it provided some relaxation and adaptation, as well as plenty of time for the Europeans to vacillate before the anti-Nazi coalition was created against all odds and despite the isolationism of USA and alienation of Russia.

To summarize, the configuration of WW2 was very archaic, as far as its motives and outbreak were concerned. There is very little complexity to be found in it. It followed the prehistoric pattern of aggressive attack, invasion, conquest, and plunder that dominated ancient and medieval history as well as epic mythology. Every empire grew in this way and was beaten in the same way either by Hyksos, Goths, Vandals, Huns, Vikings, and Mongols or by another empire.

To quote Stoessinger:

> In looking back on these events, one is struck by the private and personal nature of Hitler's war against Russia. The need to destroy the hated Slavic nation weighed upon him like an oppressive presence and blinded him completely to the strategic realities in Russia, both before and after the invasion (Stoessinger, 1974, p.47).

WW2 was, probably, initiated in the dark nature of the powerful absolute dictator more by the internal tensions and historical and mythological catalysts than by anything else. As we believe, WW2 illustrates the timeless vitality of patterns that can survive in an encapsulated form in the historical soil for long periods of time and then spring up as an epidemic, the situation described by Albert Camus in his parable *The Plague*. Historical patterns have ninety-nine lives.

The pattern of the private war was repeated in Bin Laden's venture against America, this time, without the legitimacy of a nation-state.

One major misperception of Hitler had "historiophysical" roots. Britain, USA, and Russia by that time were free of major internal stress—the result achieved by different means in Russia than the other two. As a counterexample, the Western Roman Empire in her last century was torn apart by internal hostility between the privileged and impoverished classes. Most important, contrary to expectations, Britain, USA, and Russia were able to form a temporary military coalition despite their ideological rift. Following yet another pattern, however, too close ties are prerequisite of a conflict: the Cold War quickly followed WW2.

The consequences of WW2 were profound on an unprecedented scale. The initial result was not only the breakup of the colonial system and even some nations, but also the polarization of the entire world between capitalism and Communism. Almost immediately, a new stress was created by another ego of the same scale as Hitler's: the ego of victorious and paranoid Stalin.

The Cold War was presented by propaganda as a typical metastable state because of the fingers on the nuclear buttons, but its energy was dissipated in enormous military spending instead of a world fire. The top point of the transition barrier had not been reached and the hot WW3 never happened not because the barrier was too high. In the Cuban Missile Crisis of 1962, the movement toward WW3 was reversed and the sides rolled back to the initial state, not exactly the same, of course.

As we believe, it was an excellent example of the power of historical experience as well as of direct interactions of patterns of ideas with patterns of action. Some new factors raised the crest of transition toward the war.

It was possible to reverse the Cuban conflict because the crisis could mean WW3 while WW2 and even WW1 were still very much alive in memory. Both leaders, John Kennedy and Nikita Khrushchev were WW2 veterans (Khrushchev was veteran of two world wars and one civil war) and had unlimited power in military matters. At the same time, it was still the period of the Soviet thaw, when the autocratic pattern of Stalin's rule was denounced and there was a kind of collective decision-making in the ruling oligarchy. The thaw ended in 1965 with the first political trials of dissident writers.

The major factor, however, was the nuclear weapon. For the first time the big gun smokers were tormented by the terrible smoker's dilemma. In the entire previous history, war meant either victory or defeat or a draw. This time war could bring self-destruction.

Therefore, the WW3 was averted because of an extremely high transition barrier in combination with the democratic or quasi-democratic pattern of society where the leaders could not simply follow their basic instincts. The liberal Kennedy was forced to be tough and militant Khrushchev, not a hawk by his nature, was forced to be weak.

However it might be true that the Stoessinger's empathy is a recipe against the war, the good old self-interest works well, too.
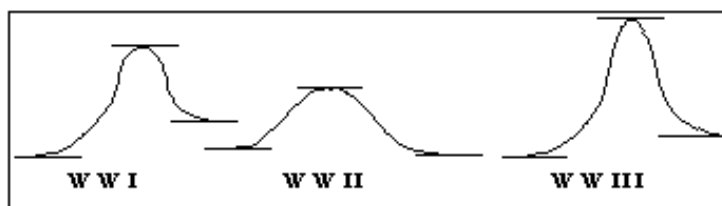

Figure 22.4. Transition states of world wars

To summarize, Figure 22.4 compares the transition situations of the three world wars: if we take the historically "normal" transition state for WW1 as standard, the height of transition

state of WW2 was drastically decreased by an ego enormously amplified in a totalitarian state, and the barrier for WW3 was increased by the previous European experience and nuclear factor combined. If WW1 could be considered a historical accident, two such wars in a row were already regularity.

All three wars, two hot and one cold, were won by the mainstream West. They caused even more fragmentation in the world, but the fragments started moving toward a new integration and a new geopolitical topology, with charismatic leaders playing less and less role in history, for better or worse. The charismatic leaders are now presidents and CEO's of companies, often in charge of resources comparable with resources of many nations, and with income well above those of state leaders, while very few of them try to run terrorist corporations.

In this book, however, we deliberately evade the extremely important economical aspect of history because of our limited qualifications. It could be a rewarding terrain for a pattern historian to compare patterns of classical heroes and villains with their modern transplants into corporate life sanitized by the spray of democracy.

Researchers in history of modern corporations may find someday that the pattern of world wars was repeated on a smaller scale by large corporations, and Microsoft comes to mind first. World markets seem to be still in the "medieval" pre-United-Nations stage when territorial conquest is possible.

Looking back at the twentieth century, we may see it as the century of the single Anti-war Revolution, comparable to the Industrial Revolution. Big world war becomes unthinkable. To ask whether the probability of a new world war is at the lowest point in a century, however, is the same as to ask whether a stock has reached its bottom on the market: such questions could be projected only backwards and only for a specific time span. From the present, we can see only

one hill ahead and we might err in evaluating its height, but definitely we cannot see whether there is another hill or a precipice behind.

Our major objective in this chapter was to show that the pattern paradigm, even without going into detail, provides some means to shuttle between major components of historical process—actions and ideas—without changing the terminology. To be seriously explored, the concept of transition barrier and the factors that influence its relative height needs professionals and not amateurs like ourselves.

Finally, without claiming any prophetic powers, we would like to share the observation that each of the three pre-world-war situations were preceded by a new major factor of radical historical novelty. It was the new military technology and means of communications before WW1, the modern totalitarian apparatus before WW2, and nuclear weapon before the aborted WW3.

If we are destined to face WW4, albeit on a mini-scale, we owe it to wireless phone and Internet.

Whether the next phenomenon of electronic globalization can lead to the next crisis, shall be seen, but history sadly teaches us to keep the reconciling distance and beware of your own kin. Our self-made historiophysics offers a simple old recipe for peace: cool off. Conflicts are less probable if the overall level of social frustration is low, if the sides are not constrained by uncomfortably tight bonds and bear hugs, and if there is neither czar nor father of the nation, nor, most important, a combination of both.

While the wars are pushbuttoned by leaders, revolutions are not. The main conflict of the revolution is that between the leaders and the masses, which we are going to explore on the example of the French Revolution.

23. The French Revolution

Revolution is one of the vaguest terms. It means anything from short and fast-pacing violent event within national borders to a fundamental change, not necessarily violent, toward a new stage in the course of global evolution. Examples are as different as the religious revolution of Akhenaton in the fourteenth century B.C., the Iranian Revolution of 1978-79, and the Industrial Revolution spanning over centuries and still going on in some countries. The term was also applied to almost any modern change, such as sexual, technological, information, computer, Republican, and other revolutions, sometimes, tongue in cheek.

The overall pattern of radical change repeats itself not only in history of nations but also, on a smaller scale, in the life of institutions, corporations, and even families, sometimes, violently, as divorce, bankruptcy, loss, takeover, etc.

Unlike common disturbances and calamities, revolutions are rare events. On any scale, only the revolution of 1640-1660 in England can match the French Revolution. The Industrial Revolution, not a violent disturbance, had even greater magnitude. In the twentieth century, the Russian Revolution, decolonization of Africa and Asia, emancipation of women, and information revolution are the top picks.

Russia, America, and China knew only one successful social revolution each. Germany is relatively young as a unified nation, and Luther was, probably, the greatest revolutionary, humbly called reformer, of the German-speaking people. The French Revolution, however, meant not only a cardinal cataclysm of social structure, but a series of events involving large number of people over long time and considerable distance from Paris.

Big and dramatic changes initiated from the top are usually called reforms, not revolutions, but the rule of Emperor Meiji (1867-1912) who transformed Japan into a modern state, holds both titles.

Political revolutions do not prove anything and rarely accomplish their goals. After the Lutheran Revolution, Catholicism underwent a self-purification and revitalization. After the Communist Revolution in Russia, Communism became discredited all over the world. After the French Revolution, monarchy was not only restored but invigorated by Napoleon. We can only guess how the spirit of American independence is going to survive the tests of global economy and global threats and whether the spirit of Communism is going to be resurrected when energy, food, and water become scarce in the world.

> In practice it has usually been easy for political revolutionists, even economic revolutionists, to rebuild an authority to take the place of the one they rebelled against; Jacobin France and Bolshevik Russia soon made obedience respectable (Brinton, 1959, p.64) .

Over two centuries separate us from the French Revolution. All that time it has been a matters of controversial historical interpretation, less so in America. The nations whose formative revolutions have not failed tend to be sympathetic to all revolutions. Those whose upheavals betrayed their goals teach caution. New historical developments prompt to ask new questions.

On the one hand, the French Revolution was a relatively short sequence of violent acts within a nation, and on the other hand, it was a process with global consequences and major aftershocks in other countries for over more than a century.

We see revolution as a change of pattern when the old conditions of regularity do not apply anymore: new generators appear, the old connector is lost, the bond relation is no longer valid, and we cannot figure out how to deform the old template without breaking it.

Most revolutions increased freedom and made the bond relations more relaxed. But the revolution itself cannot happen unless a certain degree of chaos is not already present. Historians call it revolutionary situation. *Le bourgeois gentilhomme* by Molière, written a century before the Revolution, may serve as an illustration of the comic aspect of the relaxation of the rigid structure of the estates.

The basic sequence of events was as follows.

The Timeline of the French Revolution

1789

Meeting of States-General	(May 5)
National Constituent Assembly	(June 17)
Tennis Court Oath	(June 20)

The King recognizes National Assembly   (June 27)

Fall of the Bastille   (July 14)

Declaration of the Rights of Man   (Aug. 27)

Nationalization of the land of clergy   (Nov. 2)

1790

Reform of the Clergy   (Jul. 12)

Acceptance of constitutional monarchy

by Louis XVI

1791

Flight of Louis XVI to the Austrian border (June 24-25)

Constitution of 1791 accepted

by Louis XVI   (Sept. 14)

Legislative Assembly

1792

War with Austria and Prussia   1792-1797

Storming of the Tuileries.   (Aug. 10)

September massacres   (Sept 10-21)

National Convention   1792-1795

France is declared a Republic   (Sept.21)

1793

Execution of Louis XVI   (Jan.21)

War against Britain, Holland, and Spain   (Feb.1)

Organization of Committee of

 Public Safety   (Apr.6)

Arrest of Girondins   (June 2)

Reign of Terror   1793-1794

Decree of *levée en masse*   (Aug.23)

1794

Fall of Robespierre. Thermidor.   (July 27)

Return of Girondists to Convention   (Dec. 8)

1795

Constitution of the Year III   (Aug 22)

Napoleon's "whiff of grapeshot"   (Oct.5)

Dissolution of the Convention   (Oct.26)

The Directory   **1795-1799**

Napoleon's Brumaire 18   1799

The above record of the events is just a sequence of statements strung together by the timeline. We should fully appreciate the art of a historian who reads the hard beads of facts on the string and turns them into a captivating narrative.

Here is our own extract of many thousands of pages written about the ten turbulent years.

By the end of the eighteenth century, France, an absolute monarchy plagued by many long-term and accidental problems, entered a crisis which took a form of a violent conflict. The old social system was destroyed. War contributed to the overall social unrest. First a constitutional monarchy and later a republic were proclaimed, the King was beheaded, a succession of more and more radical and violent groups and individuals came to power, more and more heads were chopped off, until at the peak of the terror moderation took over and, in a sequence of steps, not without violence, monarchy was restored, while the dynasty and the overall social system were not.

We can see at once the difference between the chronology and the narrative: the former is linked only by temporal sequence while the links between the statements in the narrative form a semantic network which is anything but a linear sequence.

There are many alternatives to the above matter-of-fact description: in addition to Tolstoy's analogy with fermentation, the parable of epidemics described by Albert Camus in *The Plague* would fit just as well.

Crane Brinton, an American researcher of the French Revolution and a contemporary of Pitirim Sorokin, described the same events in similar terms: as fever that starts with certain symptoms, comes and goes, reaches the stage of crisis (delirium), breaks, and turns into convalescence with recurrences of pathological signs.

A series of other analogies could be offered with a certain invariance of main physical features: the event starts, grows, culminates, and subsides. Unlike seasonal flood, epidemic, forest fire, or disease, however, the system that produced the catastrophe is forever changed. The Black Death of the fourteenth century had killed at least 25 million Europeans but it did not change Europe politically, while the French Revolution with its 40,000 victims meant a radical turn for the continent.

We may regard the entire decade between 1789 and 1799 as a transition state between two monarchies. Each shorter event within this period, for example, the storm of Bastille or the period of Jacobin terror, could also be split into initial, transition, and final states.

Figure 23.1 gives an idea of how a larger transition state can be fragmented into sub-stages. Historical events have the same fractal character as many other natural phenomena. Thus, shoreline repeats on a smaller scale: the bay has smaller coves and each cove has its own little inlets.

Figure 23.1 presents only a fragment of a larger historical picture, see Figure 21.7, but the shape of both is similar. Of course, there are more than one way to do that.

The horizontal axis is the historical time measured not by the clock and calendar, but, in the spirit of Gottfried Wilhelm Leibniz and Ilya Prigogine, by the sequence of events, so that if nothing happens, the time does not move.
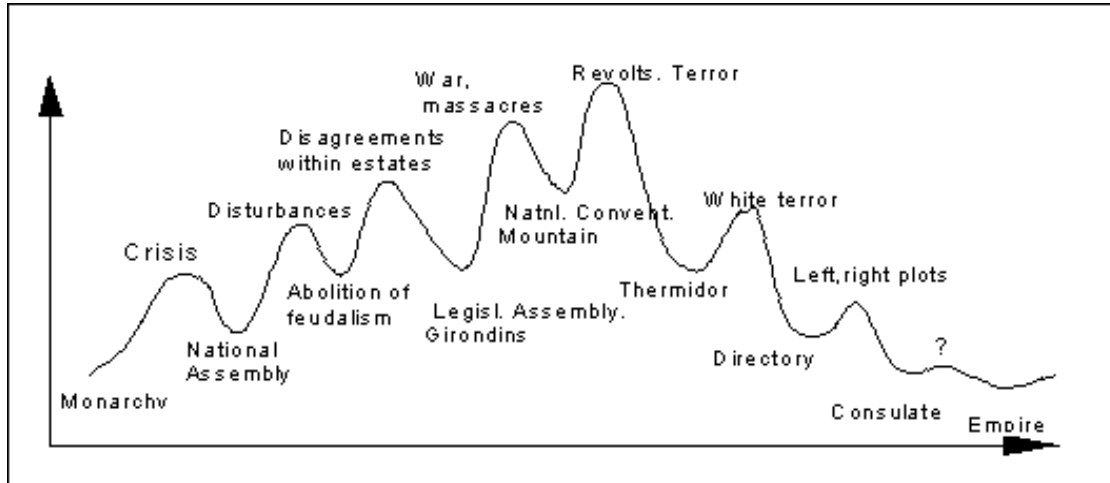
Figure 23.1. The energy profile of the French Revolution

The vertical axis means abstract temperature or degree of chaos. It can also be interpreted as energy. In Chapter 25 we will try to elaborate this point. What is important, regularity is relaxed at high temperature, positive bonds tend to break up, and negative bonds, for example, law and order, are difficult to maintain. If normally regicide is an extraordinary and unthinkable event, the fatal decision can be made easier in the heat of the moment. Thus, the agony of the Great Depression lowered the windowsill for the desperate.

Although France was a monarchy in both 1789 and 1799, the two situations were radically different. The process of the transition was violent and intense, culminating in the inhuman, cruel, and apparently irrational Reign of Terror.

The words like "inhuman, cruel, irrational" make sense only in the modern interpretation. We do not allow public executions and cruelty to animals, but the physical elimination of the enemy has been a norm throughout millennia. There is a big literature on the troublesome problem of aggression, see, for example, Chapter 5 in *On Human Nature* by Edward O. Wilson (1978). The reductionist explanation in this case seems natural: we are animals.

Historians are unanimous on the importance of the idea of equality for the French Revolution, but hardly anybody asked about the origin of the *idea* of terror, so old the idea, as well as practice, had been. There could be specifically French roots of terror, however. The Saint Bartholomew's Massacre might have established a pattern.

Once a template comes to existence, other configurations under the same pattern are no more irrational: they follow the pattern. A pattern historian must look for catalytic templates everywhere—as naturally as a biologist looks for the template of DNA.

The French Reign of Terror, so repugnant to many of us, was highly praised in Communist Russia and a copycat Reign of Terror was established after the Bolshevik Revolution of 1917. It lasted, with declining intensity, until 1986. Many streets in Russian cities were named after Robespierre and men were named after Marat.

The origin and evolution of patterns of cruelty could be an important subject in our times when they resurface time and again. Looking for reasons of the terror, historians often address, and with good reasons, the personalities of such people as Robespierre, Hitler, and Stalin, but we cannot dwell on that. The question we are more interested in is why revolution or another mass movement is capable of achieving a high level of chaos, hysteria, and violence,.

The barrier from a peaceful life to terror seems extremely high and difficult to overcome. While an average person cannot jump over ten steps of a staircase, everybody can walk it up step by step. During a stepwise ascent through intermediate steps, each smaller step is separated from the next with a low barrier.

Looking at Figure 23.1 we can see how the extreme radicalism of the French Revolution became possible. The Jacobin terror could not start right after the beginning of the Revolution because the jump would be too high to accomplish. Each step up, however, should be counted

not from the initial level but from the previous relatively stable intermediate state. What would seem unthinkable after the peaceful beginning could be natural against the background of the previous tumultuous state. Thus, the Reign of Terror under Robespierre was just another increment over the terrors of the war and the atrocities of the Montagnards under Danton.

This phenomenon is known as escalation, and history of modern time contains many examples of it, as well as that of de-escalation. The rise of Nazism, the Vietnam War, the violent rise of Communism and its long decline, break-up, and return to a quasi-bourgeois state also fall into this category. The gradual pacification of the Middle East is another example of a stumbling de-escalation. The anti-American and world terrorism, too, present a perfect case of escalation over three decades. A series of successes in acts of increasing magnitude encouraged the Islamic extremists to scale up the destruction.

The stepwise pattern is not limited to politics. The same effect makes the utilization of energy in living organisms possible: the energy of food is released not all at once, as in burning, but in a cascade of small steps of gradual oxidation.
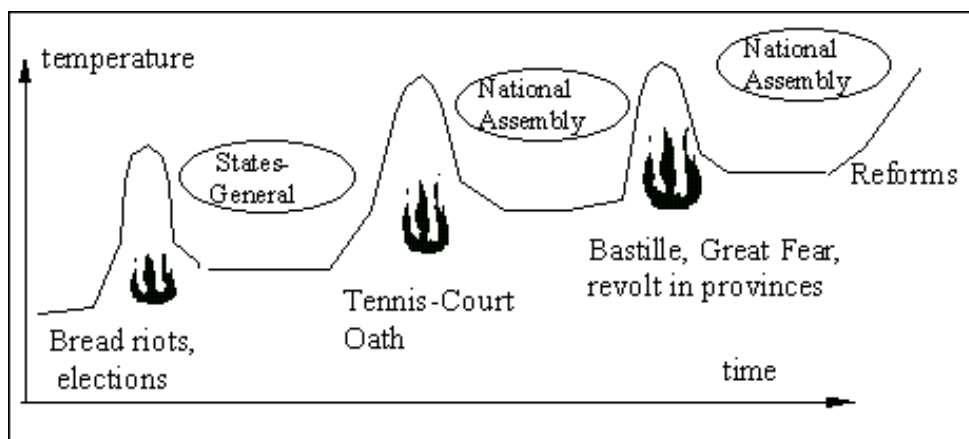

Figure 23.2. The rising temperature of the representative body of France

Figure 23.2 focuses on the first steps of the French representative body, from States-General to National Assembly with constitutional monarchy, over one barrier after another to more radical actions, each time pushed by the rising social temperature symbolized by the flame. Everybody had to make his or her own decision during the fast pacing times. Robespierre climbed his own ladder.

The change in the perception of the king lead to his demise from the majestic cornerstone of French life to "citizen Capet." It could be described in terms similar to the smoker's dilemma. Both those who voted for the death sentence and against it were signing their own sentence and were punished later at different moments as sympathizers of either monarchy or republic. No doubt, many voters had anticipated the double outcomes and the National Convention made its difficult decision only by a narrow margin.

If the spontaneous storm of Bastille can be described in terms of generators and bonds, those would rather be the stones, bricks, and mortar, with hardly any social structure involved, more like breaking glass or melting wax. The spontaneous mass movement is rarely structured but it raises the energy of participants to a height not achievable in normal life. The fact that the social energy can be both constructive and destructive, like work and heat in physics, gives more substance to our vague understanding of energy in pattern transformations.

The diagrams in figures 23.1 and 23.2 tell us something about the transformation and its direction but not about what is transformed. Our next objective here is to express the narrative in terms of generators, bonds, configurations, and patterns.

When we built the semantic network for the Great Northern War in Chapter 19, we did it from our general knowledge about the subject and the result was hard to manage. Let us do it differently this time and build a semantic network on a single paragraph from Crane Brinton:

In France the years preceding 1789 are marked by a series of measures which antagonized different groups. With striking awkwardness, the government offered with one hand what it withdrew with the other. Tax-reform efforts, never completely carried through, offended privileged groups without pleasing the underprivileged. Turgot's attempted introduction of laissez-faire offended vested interests; his failure to make his reforms stick offended the intellectuals and the progressives generally (Brinton, 1966, p. 34).
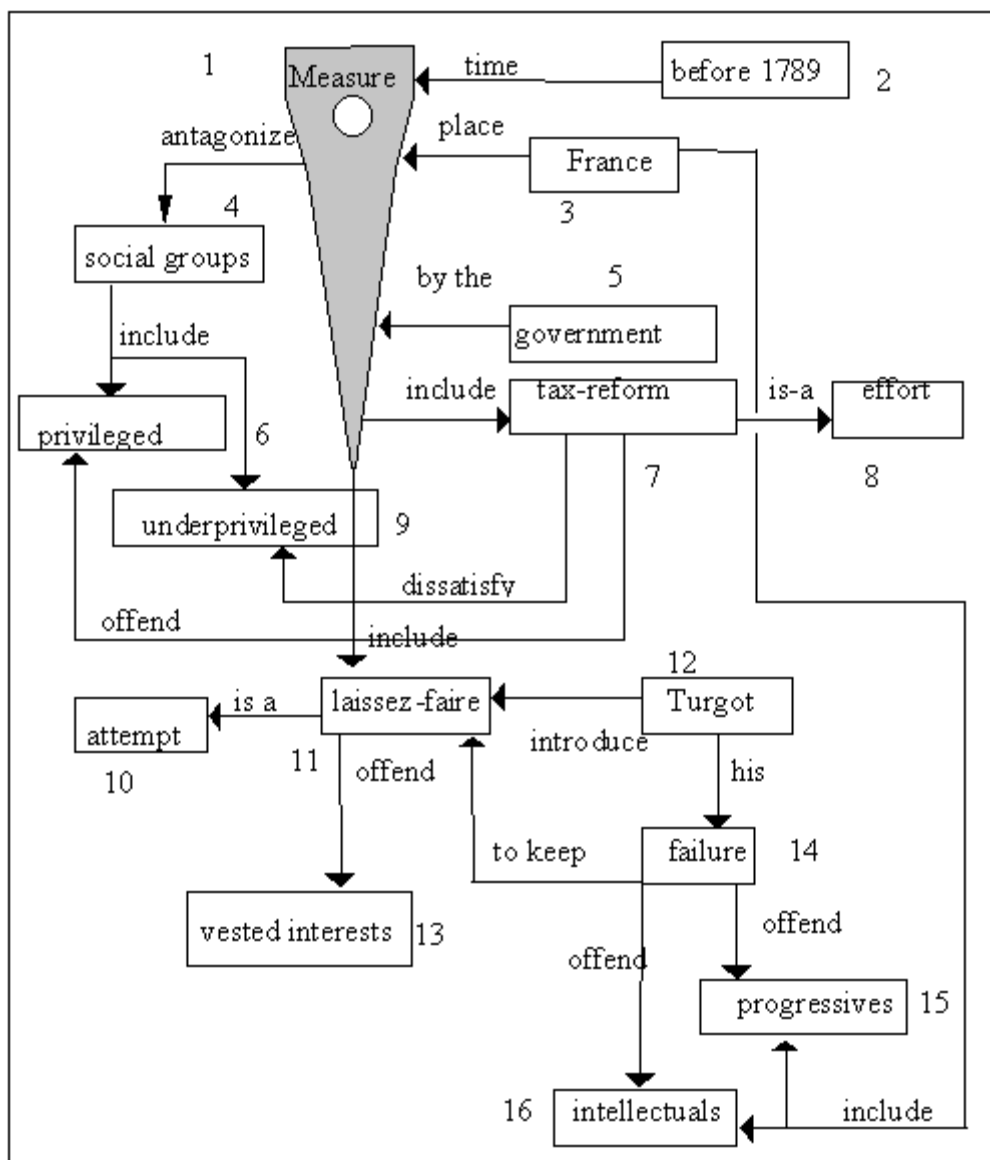

Figure 23.3. Narrative as semantic network with the centerpiece of "measure."

Figure 23.3 illustrates the resulting network. Figure 23.4 shows a small part of the network as a subconfiguration in the typical pattern notation. The bonds are oriented and the bond values are indicated on the arrows. For example, "offend" applies to the outbound bond and it means "offended by" for the inbound bonds. In Figure 23.3, for the sake of simplicity, we use a less formal symbolism than in pattern theory. Obviously, it can be done in many different ways.
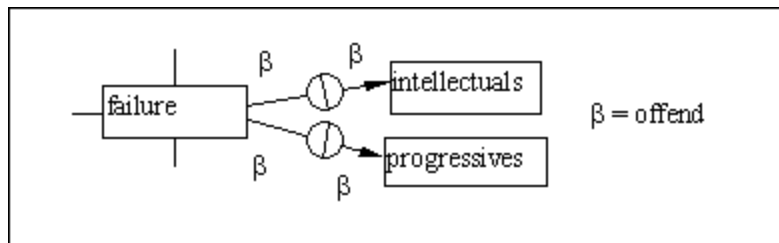

Figure 23.4. Part of the narrative as subconfiguration

A lot of questions arise. What is the right direction of the "include" arrow? Is "introduce" a node, as "failure," or a link? Is "failure" a property of "attempt"? From the short piece of the narrative it is impossible to tell whether the intellectuals and progressives are components of "France" or just belong to a common social group, etc.

Turgot was part of the government, but our text keeps silence on this matter, as well as on many other things. In a larger context we could find the link "approve" between tax-reform and intellectuals, but there is no such hint in the piece of the text. We include progressives and intellectuals into "France," but this does not follow from the text, either. Finally, what to do with "striking awkwardness" and "offered with one hand what it withdrew with the other?"

This clearly shows, as we have already noted, that semantic networks are confusing and inappropriate for historical analysis in pattern terms, and, by the way, so could be their original narratives because of the brevity, or internal contradictions, or gaps. Since there is no one-to-one

correspondence between the text and its semantic network, we can tell which translation of the

text into the network is wrong, but there is no true one. Anyway, we can see that the number of

bonds (called *arity*) is the highest around the "measure by the government," and this is where

everything starts. We even gave it the shape of an axe.

What follows from this observation, is the possibility of formal approach to evaluating

political situation. A computer in the office of the President could maintain and update the

representation of the current situation in the country in the form similar to Figure 23.3.

Generators with the largest number of bonds could be the focuses of attention and possible

sources of controversy. We will talk more on that, as well as on the ways to measure political

temperature, in Chapter 27, *History and Computers*.

In figures 23.5A to E we present configurations of selected stages of the revolution,

basing on our textbook sources. We ignore the full complexity of the developments of the

revolution. After our pattern experiments with the Great Northern War, we already know that the

basic pattern change takes place locally, i.e., in small subconfigurations.

We start with the configuration of the old regime in Figure 23.5A. The simple picture

does not reveal the extreme feudal complexity later to be simplified by the revolution. The big

ellipsis signifies France. The darker its color the higher the abstract temperature.

Three areas of internal stress depicted by negative bonds are those between the tax

burden of the Third Estate and tax privileges of the nobles and clergy, the inequality of land

ownership between the two groups, and the innate disharmony between them, exacerbated by

unequal representation. The configuration rifts cross at the point of major conflict.

The system that had existed for centuries without major stress was knocked off its

equilibrium by a system of immaterial ideas developed by *philosophes*, French intellectuals of

the eighteenth century. One of them was the idea of equality of all people before the law,

implying equal representation, taxation, and the right to own land. That idea implied a kind of

regularity incompatible with the existent pattern.
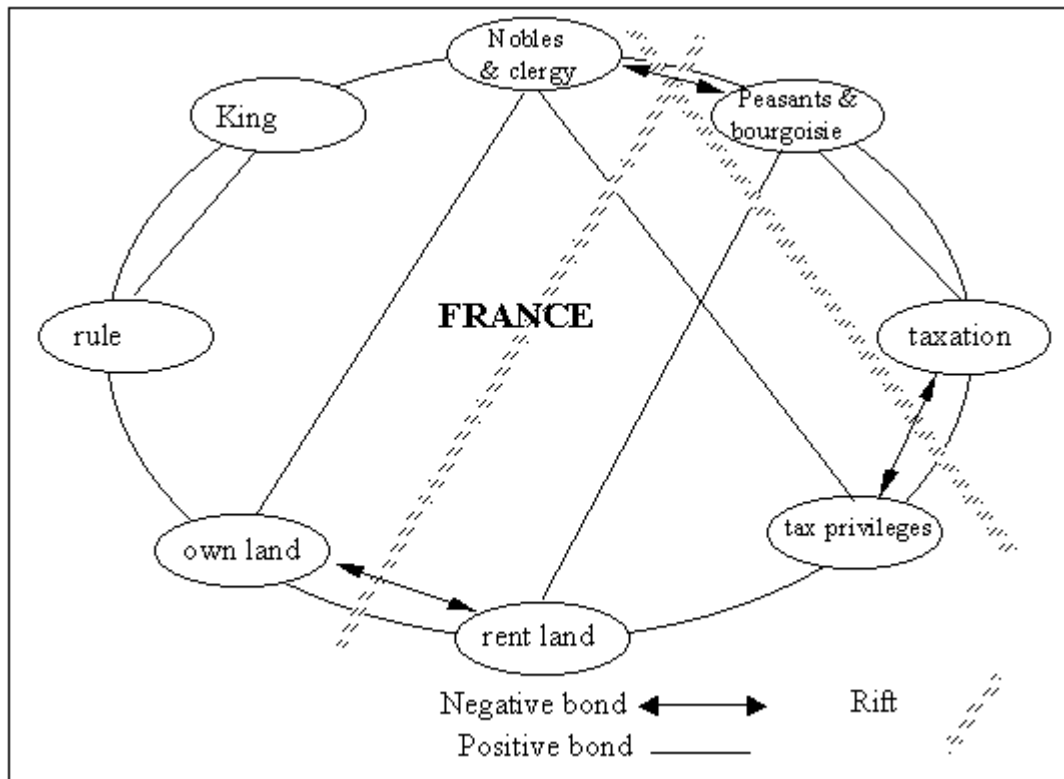
Figure 23.5A. The Old Regime

The ideas of *philosophes*—mental patterns, we should say—were by no means new by

1789. Rousseau, Voltaire, and Montesquieu had been since long dead. What the ideas of the

philosophes did was creating an internal stress, a discomfort between the vision of a better world

and the reality, see Figure 23.5 B. A society can live with uncomfortable ideas for a long time

because of the transition barrier between thinking and action. In order for the entire society to

display ability to act in a synchronous way, something must act on all members of a large part of

the society indiscriminately. order in the form of law is one example, idea is another, and temperature (stress, frustration, chaos) is the third. In the age of TV it is the image that substitutes for idea.
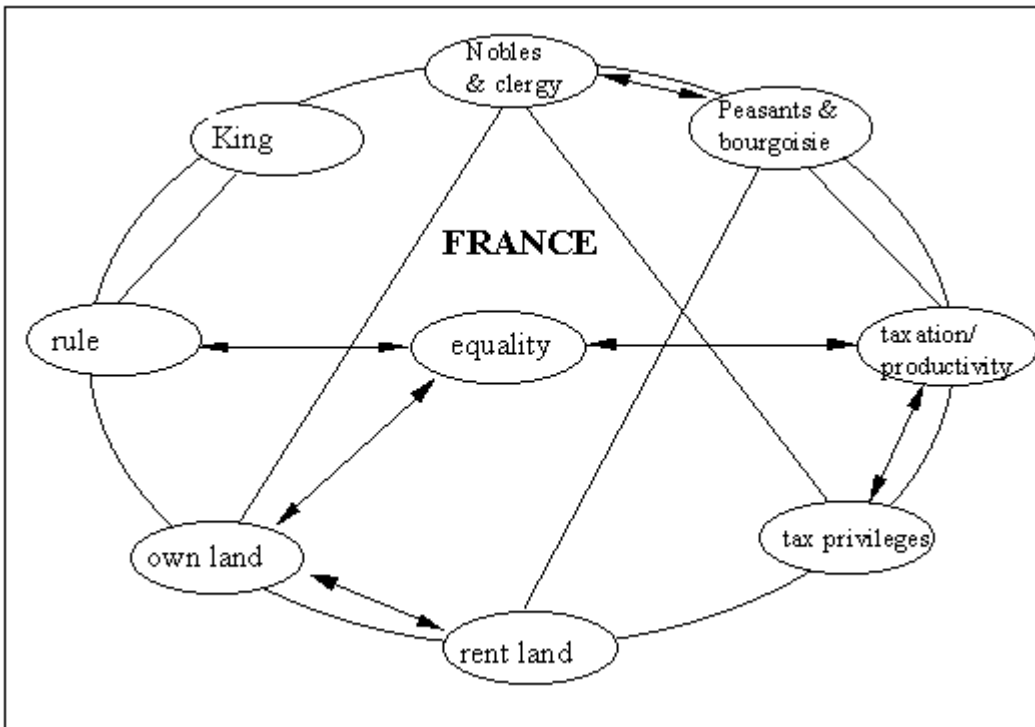
Figure 23.5 B. Equality enters the picture; the rule weakens

The level of frustration was increased by the combination of the financial crisis with the poor harvest and hunger that destabilized the population of Paris, see Figure 23.5C. The temperature here is rising as the flames burn at particular points.

In this picture we can see a new generator—Estates-General—which only adds to the internal tension because of the inequality of representation.

Could the events take a different turn? If there was a tension in the government, why did not the King relieve the tension, appoint an appropriate progressive minister, and redistribute the pattern of wealth, power, and taxation? The answer, along the principle of reductionism, would

refer us to the personality of the King. We probably have to go back to his childhood, upbringing, heredity, physical problems, and influences in order to get more information, but the element of chance is always present.

If the King were a different person or there were strong influences on him, history could take a different turn, and an imaginary historian could write:

In France the years preceding 1789 are marked by a series of measures which united previously antagonized groups. With striking political ingenuity the government passed a set of profound reforms. Tax-reform efforts were consistently carried through. They decreased the power of privileged groups and improved the position of the underprivileged. Turgot's attempted introduction of laissez-faire failed, but his overall success reconciled both the intellectuals and the progressives with him.and each other.

Why was it not possible? Exactly because it required a high efficiency of the government, which was not the case, as we saw. The "striking political ingenuity" is directly opposite of "striking awkwardness." If in 1788 we expressed the above statement as a political prognosis, it would contradict the facts. The entire system of our knowledge would be stressed, "frustrated," like the poorly designed kettle, according to Christopher Alexander, and made unstable by negative bonds in its configuration.

In Figure 23.6 we present the conflict between assumption and fact as a stressed, irregular configuration for the pattern of the Spinoza's correspondence between thoughts and things. Let us consider this as an illustration to the problem of truth that we have been avoiding until now. Truth is a representation of knowledge, facts, opinions, and theories with minimal overall number of contradictions. Taking to account the statistical nature of any such number, we may

have a couple of equally true theories. Taking to account the dynamic nature of social and individual patterns, the truth has a limited life.
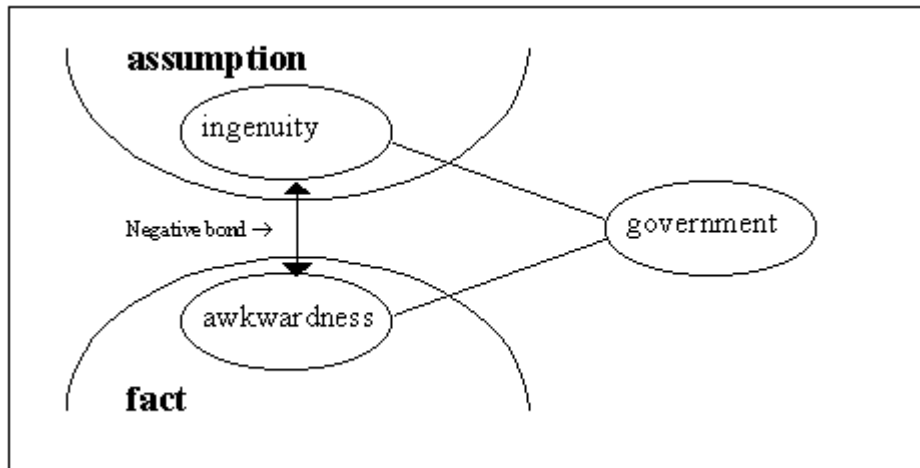
Figure 23.6. Assumption and facts

There are usually good reasons why history takes its course. We can imagine a plausible counterfactual scenario, but this would require an alternative previous state, which in turn would make us play mental games with its previous state, and so on.

Instead of a glorious and velvety resolution of the conflict, France moved another level up on the scale of energy and ladder of violence.

The King did not do anything extraordinary: his reasonable step was to call the Estates General and give an unprecedented concession to the Third Estate: their representation was equal to two other estates combined.

The unsettled question of how to vote, by estates or by individuals, separated the Third Estate from other estates and made it the dominant force.

The apparently totally unrelated taking of the Bastille precipitated violence and demonstrated the Parisian mob's support for the National Assembly.
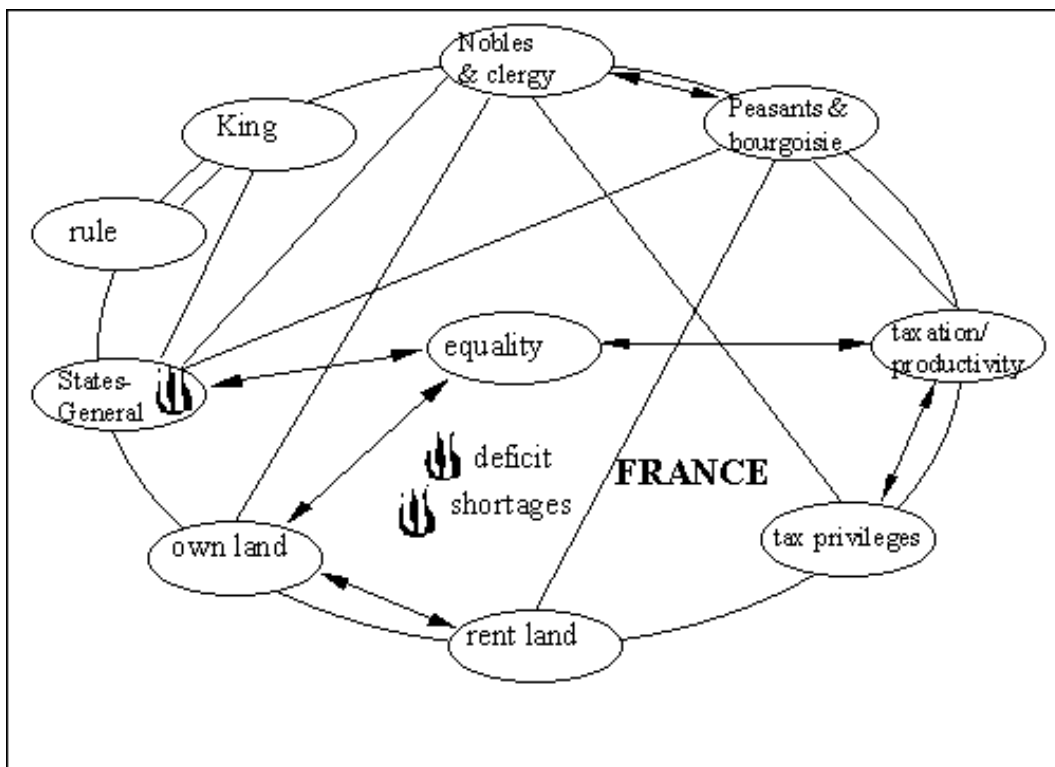
Figure 23.5C. More tension, more heat

Therefore, the power shifted from the King to the Assembly and the mob.

Although the social tension subsided, the temperature reached the level of mass hysteria, Figure 23.5D. The exodus of the former privileged estates and an attempted flight of the King ended up in the outbreak of popular hostility toward him, Figure 23.5E. The king was executed, the reign of terror began, and Robespierre moved closer to dictatorship.

"The government of the revolution is the despotism of liberty against tyranny," said Robespierre, the grand master of demagogy. Karl Marx later reformulated it as dictatorship of

proletariat, and Lenin, Mao Zedong, and Fidel Castro applied in practice as means of self-preservation of revolution, i.e. making permanent what was by definition a transient state.

At this stage, without monarchy, the pattern of despotism in France dominated despite the presence of the National Convention and the most democratic Constitution of 1792, postponed by the Convention. The real power was in the hands of the Committee of Public Safety, aided by the Committee of General Security and Revolutionary Tribunal. "From the standpoint of administration, the Terror marked both an anticipation of twentieth-century dictatorship and a return to the age-old French principle of centralization" (Brinton, 1966).

If we reformulate "the age-old French principle" as pattern, we can vividly see it twisted and torn by powerful invisible hands to be reshaped into a completely different template of equality and representative democracy. Even though we see the republic on the surface, however, the new despotism grows underneath. France was destined to swing between both for two more centuries until, after many painful experiments, the contemporary hybrid of strong executive power with democratic elections was achieved.

We can see the same evolutionary struggle of traditional centralization and new democratic forms in the history of Russia in the twentieth century, with the centralization taking form of Stalin's despotism. Russia started to swing between freezing and thaw, with declining amplitude, along the timeline of Stalin—Khrushchev—Brezhnev—Gorbachev—Yeltzin—Putin, trying to reconcile democratic and authoritarian principles, but still moving through the erosion of despotism toward democracy. The French pattern of reconciliation may fit Russia in the end.

From this moment, the revolution moved toward self-extinguishing, Figure 23.5F.

The tension eases with the coup of Thermidor against Robespierre. The revolution starts its descent and relaxation toward an intermediate stable state of Figure 23.5G, still hot enough because of the war, and further to the restoration of the empire, Figure 23.5H.

The diagrams in Figure 23.5 represent a step off the complexity of the narrative and its semantic network. They are still complex, involving many bond couples and simultaneous events, but at the same time, to be understandable, they need a lot of explanations outside the pictures, actually, the full narrative.

The next step in simplification is to go to a smaller scale.

Pattern theory, because of its atomistic nature, regards revolution as a sequence of small elementary steps, almost as Leo Tolstoy would like to see history, but by no means infinitely small. The quantum of history is a change in single generator or a single bond couple.

When we start minimizing the configurations of the narratives and excluding the sub-configuration that do not take part in a transformation, we come to a few elementary *generators of transformation*. Those are, so to say, atoms of change.

There is but a limited number of possible changes which can happen to a small pattern: a new bond couple can be established by connecting two generators, or an existing link can be one broken, or a generator can disappear from the scene, or a new one can just pop up out of nowhere, etc.
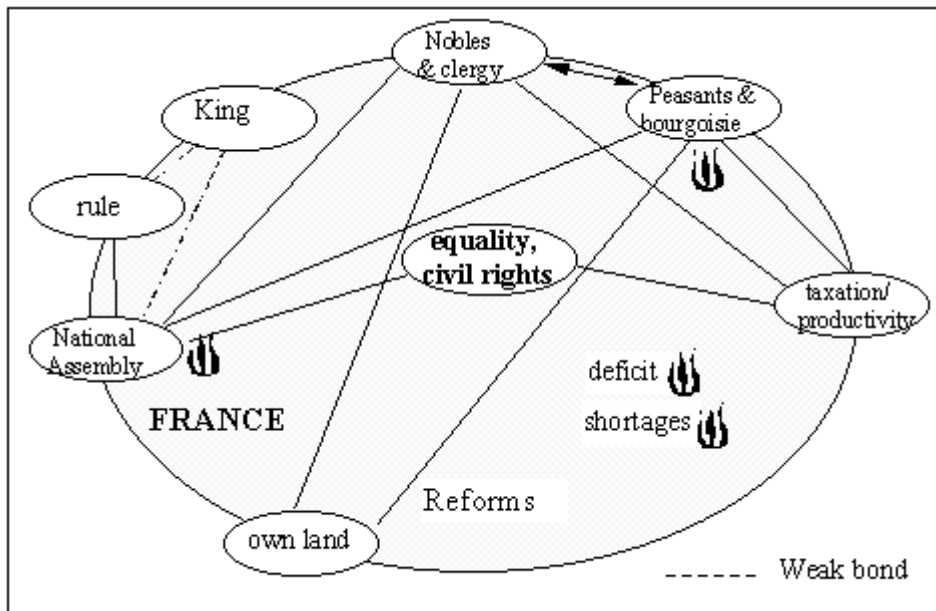
Figure 23.5D. National Assembly is taking over
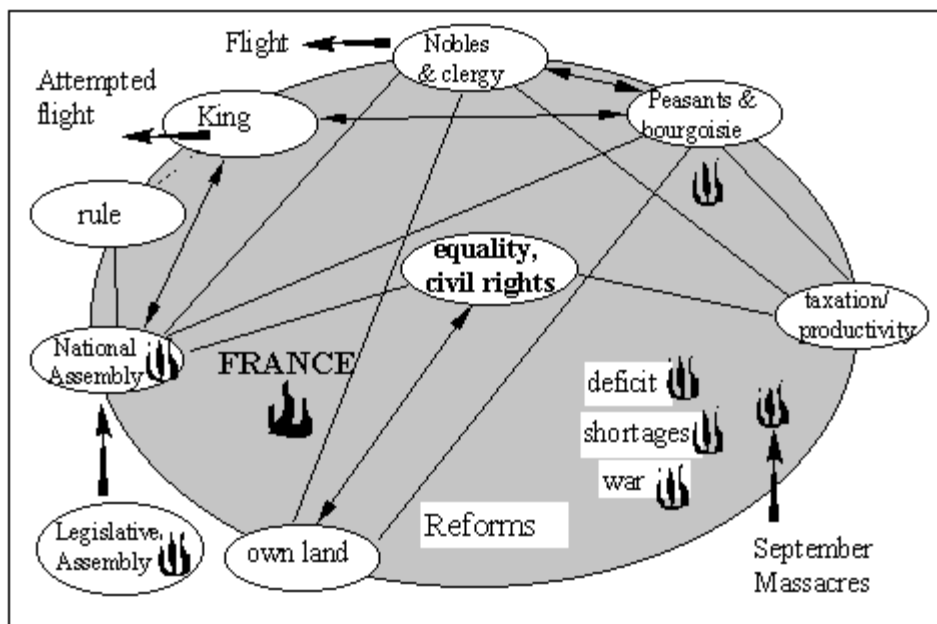
**Figure 23.5E. The king is alienated and eliminated,
the temperature shoots up**
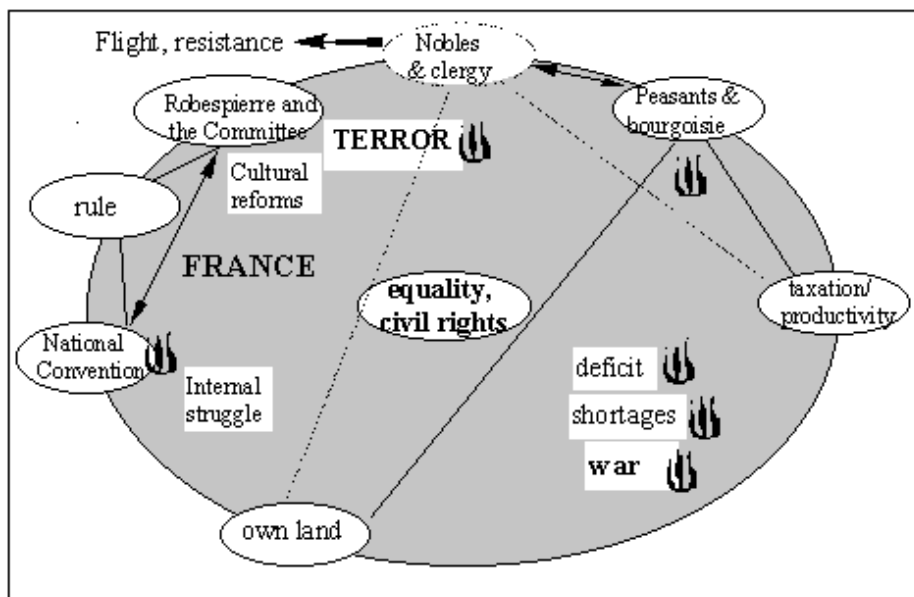
Figure 23.5F. With terror, France is red-hot, but less stressed.
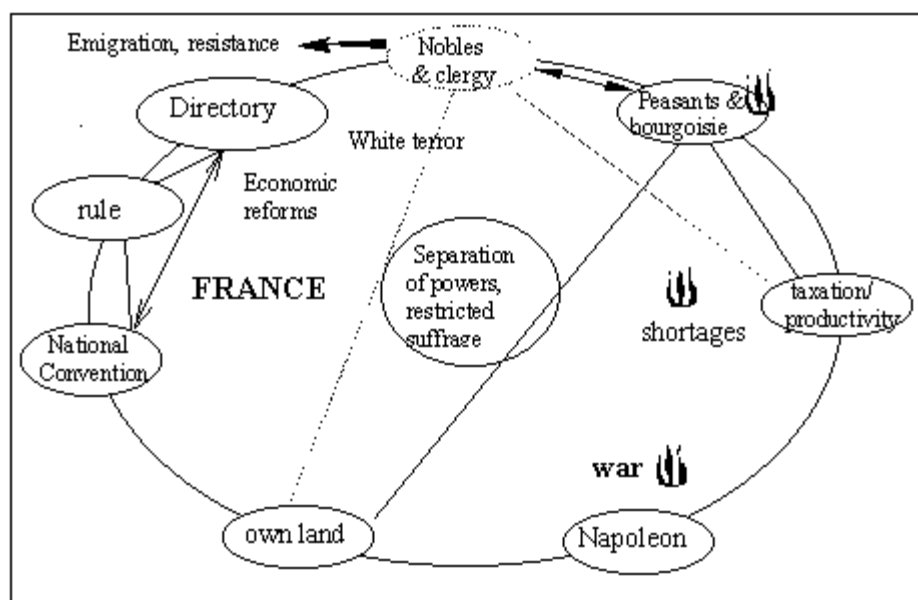
Figure 23.5G. Thermidor
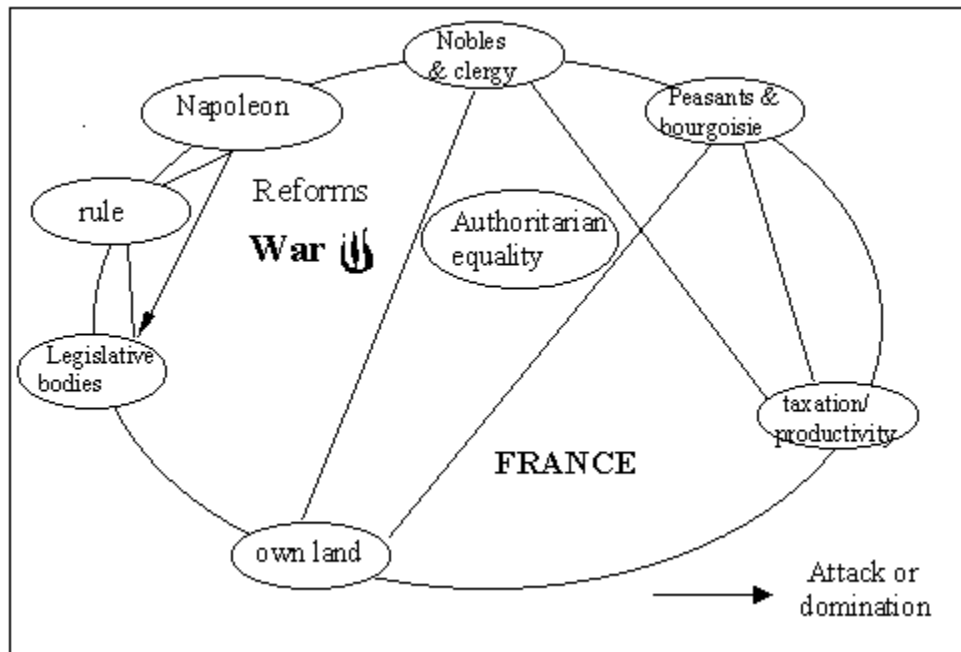
Figure 23.5H. Empire restored, equality confirmed, temperature down

The minimal changes are all performed by the elementary operators: ADD, DELETE, MODIFY, CONNECT, BREAK, see Chapter 18, *Conflict.*

In a dramatic play, even of Shakespearean magnitude, the characters practically never talk all at once. In opera more than four voices rarely sing different parts in an ensemble. Similarly, both historical and chemical transformations, however complex, are in fact sequences of small-scale events which can be perceived one or two at a time.

As José Ortega y Gasset said, " ...if the world is composed of things, these will be given me one by one" (Ortega y Gasset, 1957, p. 63)

This kind of simplification by breaking a complex whole into fragments is analysis typical for natural sciences, from calculus to chemistry, biology, and sociology. The synthetic

view emphasizing the primacy of the whole rather than parts is sometimes called holism. We may regard thermodynamics holistic. Pattern Theory, with its focus on interaction of fragments and the concept of global regularity, combines both analysis and synthesis.

Structural changes can be compared with hiking from one valley to another on a certain energy landscape with the valleys of stable states and the crests of the transition states. We need, however, to make and important remark: when we talk about the energy landscape, it is much closer to a real three-dimensional landscape than we might think looking at Figure 23.1. From every point of the valley there are several possible passages to various nearby valleys over the separating ridges.

Figure 23.7. Peaks and valleys

The topography of the energy landscape is similar to that of a mountain range, Figure 23.7. The analogy, however, should not be taken literally because the energy landscape does not exist in the 3D background space. It is a configuration formed by two kinds of generators, peaks and valleys, so that a valley can be connected only with a peak (Figure 23.8).

Any planning—economical, political, military, or personal—involves a mapping of alternatives. We rarely know what expects us behind a ridge: a deep ravine or a short ledge on the next slope. Usually not only most of the alternatives are unknown before the action, but every move may instantaneously change the landscape if we act against adverse circumstances or an intelligent adversary whose logic we cannot comprehend.

It is appropriate to recall here the ideas of Conrad H. Waddington (1957) who was, probably, the very first to offer the concept of evolutionary landscape, well ahead of time. He imagined individual development of an organism as a ball rolling over a descending landscape. Deep valleys prevent the embryo from jumping over the ridge to a route other than genetically determined, while a shallow terrain makes a change of direction or divergence more probable. Edward O. Wilson comments that human behavior follows a less stark topography and valleys can divide :

V : valley
P: peak

Figure 23.8. Landscape pattern

> The developmental topography of human behavior is enormously broader and more complicated, but it is still a topography. In some cases the valleys divide once or twice. An individual can end up either right- or left-handed. If he starts with the genes or other early physiological influences that predispose him to the left hand, that branch of the developmental channel can be viewed as cutting the more deeply. If no social pressure is exerted the ball will in most cases roll on down into the channel for left-handedness. But if parents train the child to use the right hand, the ball can be nudged into the shallower channel for right-handedness The landscape for schizophrenia is a broader network of anastomosing channels, more difficult to trace, and the ball's course is only statistically predictable.
>
> The landscape is just a metaphor, and it is certainly inadequate for the most complex phenomena, but it focuses on a crucial truth about human social behavior (Wilson, 1978, p. 60).

Social pattern can be regarded as counterpart of genotype. What sociology discovered among other things was the extent of the ability of humans to be irrational and unpredictable

(Pareto, 1935; Collins, 1982). Social psychology also provided a lot of insight about the intimate mechanisms of social pressure.

In the game of chess, where the role of chance is strongly minimized, the player can see a large area of the energy landscape, and each neighboring valley means the opponent's possible response to the move. Theoretically, the entire landscape of the game pre-exists, but it is so large that even a computer cannot see it all.

In the modern science of history it is usually a good style to outline major historical alternatives. Social evolution is, therefore, a constant choice. We can say the same about any individual life.

We are forced to be free. Because of this, life is a permanent crossroads and constant perplexity (Ortega y Gasset, 1957, p. 58).

Since history is made not only by masses and historians but also by individuals and their choices, each historical development is an interaction of the crowd with its outstanding participants. In the language of natural sciences, history displays in a chemical substrate where some molecules have no duplicates and their behavior can be described only in quantum and probabilistic terms.

To what extent is an individual really free to make his or her choices? To what extent is historical process deterministic? Is the social evolution really a natural process? Is there anything unnatural in nature, then? There is a multitude of exciting—as well as eternal—questions, which are mostly a matter of definitions. Patterns do not take to consideration the difference between masses and individuals, things and ideas, nations and chemical substances.

The difference between the war and the revolution is that the war is a sequence of big decisions made by a limited number of individuals and smaller decisions made by a getting increasingly thicker tree of subordination. The enemies attempt to move strictly along the valleys, although they may not have the right map.

In the revolution, the high temperature pushes the society to the unstable position on the edge of a plateau, from which there is more chance to fall down than scale another height.

The pattern of authoritarian rule emerging from a mass revolution plays the same role as the equipment of a mountain climber—chokes, hooks, and ropes—to secure the position. Thermodynamically speaking, the authoritarian rule uses energy in the form of work for freezing its own pattern, preserving it from deformation by the chaotic heat of spontaneous discontent and organized work of the opposition. How far this use of society as a refrigerator can go we will see from the next chapter.

24. The fall of the Soviet Empire

Russia of the last decade of the twentieth century seemed to confirm its reputation of a nested doll of mystery, conundrum, enigma, riddle, and puzzle. Although our primary interest is limited by the title of this chapter, a brief historical overview would be helpful.

For an objective, factual, and comprehensive review of the former Soviet Union on the eve of the upheaval see: *Soviet Union: a Country Study* (Soviet Union, 1982). Two lively books by David Remnick, *Lenin's Tomb* (Remnick, 1993) and *Resurrestion* (Remnick,1997), seem to be the best American account of the collapse of the Soviet Union.

Russia entered the twentieth century as an ossified absolute monarchy with no parliament and civil liberties whatsoever. Ironically, czar Alexander II, who since 1855 had made important steps toward liberalization and introduced a representational system of local government, was killed by revolutionaries in 1881. Lenin's brother had been executed as a co-conspirator, which greatly contributed to the shaping of Lenin's personality.

Russian collective mind has always been split between the gravitation to Western Europe, the heir of the Western Roman Empire, and the view of Russia as the Third Rome, a self-appointed heir of the Eastern Roman Empire. For the west-oriented Russians, autocracy and czar were blood enemies, and for the self-oriented ones the strong centralized power was the foundation of society.

The murder of the czar had derailed reforms, and the subsequent history of Russia of the twentieth century unrolled as a "what if" spin-off from the French Revolution.

The unlimited political power and spiritual authority was combined in the person of the czar. After Peter the Great, the Russian nobility as a whole did not try to limit the power of the czar, and the clergy was no rival either. This pattern explains the famous Russian patience and stoic acceptance of fate, as well as the rebellious spirit compensating for the compliance. A Russian, treated by the authorities like an immature teenager, combined obedience with suppressed anarchy. The instinctive challenge of law and order has been wide spread at all levels of society, which contributed to the post-Soviet disarray.

The Russian peasants and craftsmen unknowingly implemented the Jean-Jacques Rousseau's principle of general will. Ironically, Russia had been a "Communist" country for centuries: she had elements of collective ownership and self-government in the form of land communes that imprinted a strong anti-individualist pattern upon Russian mentality.

The education of the upper class stood out against the illiteracy of the peasants. Nobility and peasants in Russia could be taken for two different nations, so different their culture and even language were.

A sharp contrast between the upper and lower classes, combined with ethnic diversity, was a pattern shared by Russia with the late Roman Empire. It has always been a major reason

for the weak social cohesion, along with the dissonance between the oppressive social system and smuggled western ideas. A handful of domestic Russian *philosophes* used to be punished for dissent by the czars and later by the Communists.

With time, the patriarchal traditions of the Russian society were eroded by social-democratic ideas and progress of bourgeoisie in the Western Europe. By the beginning of the twentieth century, Russia swarmed with a wide range of democratic, socialist, anarchist, and terrorist organizations, with Bolsheviks among them.

The Russian patience had a high but sharp melting point. Between 1905 and 1917 Russia went through three revolutions.

It took a couple of powerful detonators to overcome the height of the transition barrier of the first ever Russian revolution of 1905 and trigger explosive developments. First, it was the shocking defeat in the war with Japan. Second, it was a bizarre massacre of a peaceful demonstration of Saint Petersburg's workers by the czar. Spontaneous strikes and riots followed and the first Soviets, i.e., municipal councils, were organized in major cities.

The czar responded with a Manifesto promising a constitutional monarchy with civil liberties and a representative Duma (Thought), i.e., legislative assembly. The revolution followed the path of the French Revolution but with much less success. The actual control was in the hands of the czar who had the right to dissolve the Duma.

Russia was moving toward both industrialization and a new political crisis. From that relatively stable period between 1905 and 1914, the next most probable outlook of Russia could be a vigorous European democracy.

The second ("February") Russian Revolution of 1917 got a boost from the ongoing WW1. Russia, populated mostly by peasants, became a democracy, although only for several months.

Same year, excited by freedom, war, and shortages, Russia gave way to the Bolshevik Revolution, very much similar to the Jacobin period of the French Revolution. It was carried out as a coup by the Bolshevik Party, a relatively small group of professional Marxist revolutionaries supported by some workers, soldiers, and navy.

The experience of both French revolution and the Commune of Paris of 1871 was a pattern template consciously used by the Bolsheviks led by their charismatic and talented leader Vladimir Lenin who referred to French history on many occasions in his strategic and tactical works. His way to power was in many aspects different because the Bolsheviks had been in the underground for many years, and were banned even after the overthrow of the czar.

The Marxist ideas and goals pursued by the Bolsheviks were alien to the absolute majority of Russian people. The promise of land distribution an peace in WW1, however, attracted the majority of peasants.

The Bolshevik Revolution quickly rolled over to the stage of terror. A civil war followed. The bone of contention was private property, including land. While the French Revolution at its Thermidor stage rejected the communist ideas of Gracchus Babeuf, the Russian Revolution proclaimed abolition of private property as one of its goals, which was later accomplished at the cost of great bloodshed and suffering.

The first practical steps taken by the Bolsheviks were to end the war, consolidate power, get rid of their opponents and former allies, feed the population, teach literacy, and restore the nationalized industry. We venture to suggest that they won not only by cruel repressions but also because the program fit the Russian pattern of patriarchal centralization and dependence on the master. As David Remnick noted, the Soviet system was cradle-to-grave paternalistic (Remnick, 1993). The Bolsheviks promised to take care of the people and they did.

The relatively high efficiency of both Jacobin and Bolshevik governments prolonged the high-energy transition states of the corresponding revolutions, but the Russian pattern lasted much longer, strongly catalyzed by the French pattern of terror. Lenin considered the weakness of the terror the major flaw of both the French Revolution and the insurrection of the Commune of Paris in 1871.

Only twenty years after the Bolshevik Revolution, the Soviet Union was ruled by a dictator in command of a military-style party organization controlling all aspects of life in the country. This social pattern known as Russian Communism was new and unprecedented in history because the elimination of private property, most often together with the former owners. Every resident of Russia received his or her sustenance from the government that *de facto* owned the giant country and controlled the movements of any person. The pattern was partially familiar for Russia with its experience of serfdom.

In modern language, Russia was a combination of a perfect welfare state with a perfect police state. Nevertheless, the rulers sincerely wanted to improve life of their subjects and achieved significant success. By no means the population was unhappy, taking hardships with the traditional resignation. The internal tensions in Russia were minimal and limited to the struggle for power in the ruling elite.

The overall pattern of the Soviet life was, paradoxically, very close to the pattern of a large, privately owned, and paternalistic American or German corporation, with the hierarchical structure of subordination, monetary compensation, pension plans, vacation vouchers, separate cafeteria for the top management and the workers, and work as the only meaning of life.

The capitalist pattern of social organization is a multitude of authoritarian corporate pyramids, each individual member of which freely participates in the election of the separate system of local and national government, which thereby embodies the general will.

While an American corporation is often a rigid pyramid, the Soviet system allowed a small degree of fluidity and initiative inside its units. This is why a typical conflict at a Russian institution could be a conflict between the superior and his subordinate, totally hopeless in America and modern Japan but typical for feudalism. Since the production unit was property of the government, various levels of management had a chance to prove their points to a higher authority, something like going to the suzerain's court. The Soviet writers, also members of a production unit, were even officially encouraged to take the vertical conflict as a plot for a novel.
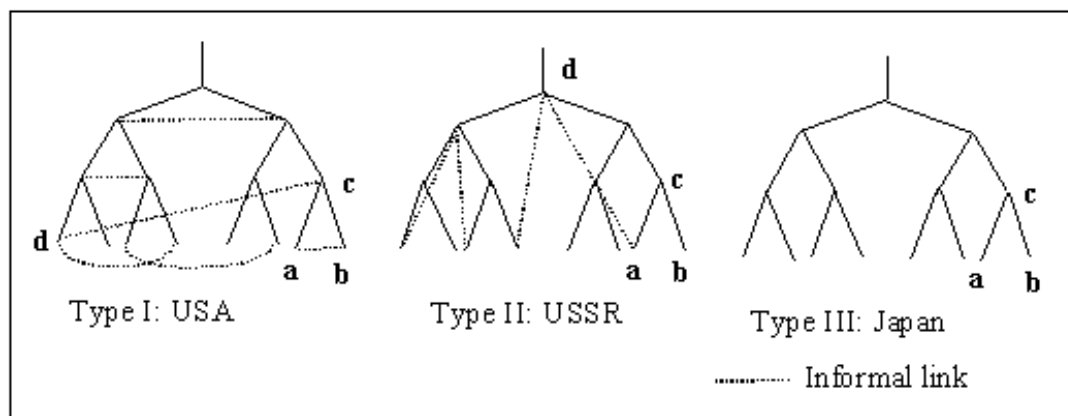
Figure 24.1. Patterns of corporate interaction in USA, USSR, and Japan

Figure 24.1 illustrates the difference between the patterns of American and Japanese corporations and the Soviet production unit. Type I (USA) presumes a relatively free horizontal interaction, type II (Soviet system) makes vertical interaction possible, at least, theoretically, and type III (Japan in the 70's) forbids any horizontal interaction of subordinates. Thus, employees **a**

and **b** can communicate only through their common superior **c**. This comparative perception of American and Japanese patterns comes from *Japanese Society* by Nakane (1972).

The stability and strength of the Soviet system had a highly regular representation, in pattern terms, both locally and globally: the social configuration was that of hierarchy. It was not built of negative bonds, however. Antagonism and dissent were kept in control by simply eliminating generators with negative bonds—as in a typical Western corporation.

The connector graph was a tree of subordination with the leader and the small group of his top deputies (Politburo) supervising the lower levels organized along territorial and industrial principles. In the Soviet Union this tree of subordination was doubled and tripled.

The dominant system of command was the party represented in any enterprise, organization, and locality, including science, education, and arts.

The Communist Party was a nervous system that did not produce anything but was designed to carry down the signals of the ruling brain, collect information at the sensors, and return it in the processed form of propaganda. The party performed the function of a powerful enforcement of the existing social configurations. Its main goal was to take care of the posts and beams of the social structure, inspect it daily, test the material strength, change the defective parts, and tighten the loose nuts. The degree of chaos in the system should be, ideally, zero.

The second hierarchy was the government, i.e., the system of professional management in industry, services, education, arts, and entertainment. The two systems were parallel and linked together by a simple device: most people in managerial position were also members of the party and so had a double subordination along both party and managerial trees. Most workers, peasants, and rank and file white collars, however, did not belong to the party.

As an example, the peasants, organized in a new kind of a land commune, were told what and when to plant and to harvest by the command from the agricultural management, and were inspired to do that by the command from the party organization. In a sense, they were the soldiers of two separate armies. Two sergeants, one from the party, the other from the management, were barking commands down the soldier's neck.

The third and less conspicuous system was the State Security that also tried to penetrate every unit of society through their agents recruited from all groups of society. The three systems were designed to prevent any irregularity in the social functions and turn society into a clockwork mechanism set by the Politburo.

Figure 24.2 illustrates the principle of the Soviet organization. A branch of the management tree lies in the plane. It can be, for example, a system of metal-producing plants, or a system of higher education, regardless of location, or civil administration of a reion. The tree of the Party superimposes on them in the third dimension, from above the plane. This means that every party organization of a certain region covers also all the other industries in this region, plus local government, medical service, education, media, and arts.

The KGB—State Security—extends its information-collecting tentacles into all organizations in the region plus the Party tree itself.

It would be difficult to draw the complete three-dimensional social structure of Soviet Russia. Figure 24.3 presents a two-dimensional projection of the connector with the three pyramids laid out along the three direction: up, down, and to the side.

The circles along the central horizontal line represent units of production, service, and culture: factory, retail shop, hospital, school, college, municipality, village, etc. They are

managed by the government hierarchy and controlled by the party. Everybody is watched by the omnipresent State Security organized geographically.
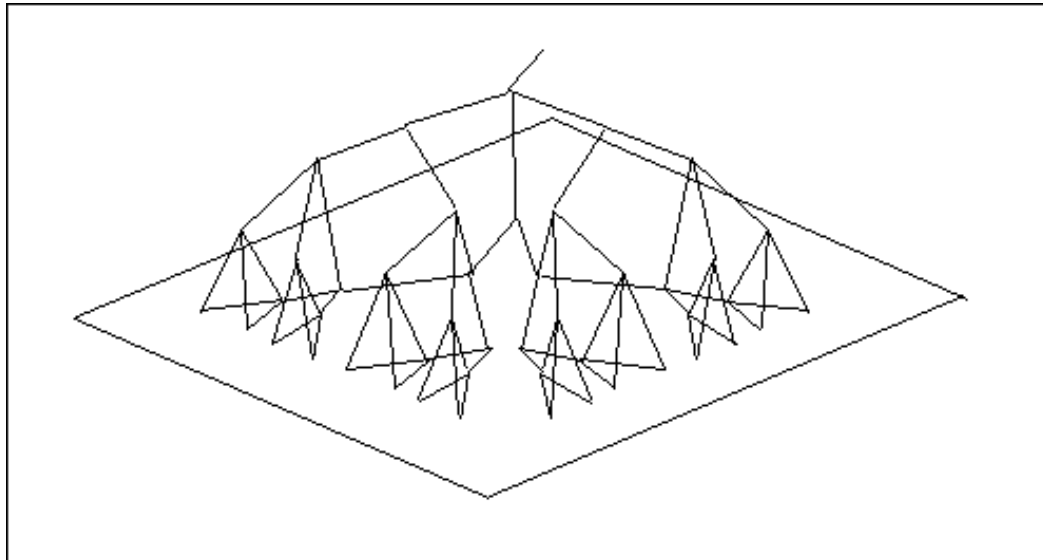
Figure 24.2. The double tree of the Soviet pattern: the government in the plane and the party above the plane.

A person in the Western society also can have two allegiances—as an employee of a business unit and as a resident of a locality—and must obey two sets of rules, but the pyramids of subordination are small and independent, the allegiance can be easily changed, and one can be self-employed and live in a boat. In the Soviet society, all the allegiances converged to the single top leader who could decide the fate of any single individual, and in fact did.

As result, the society was tied together by an unprecedented in history sponge-like multitude of links. It was a huge muscular body with a small head where all major decisions of economical, political, and ideological nature were made and where a certain level of uncertainty, intrigue, competition, and action was carefully shielded from the public eye.

Party

Primary
functional
units ○

Upper
levels □

Government

Secret
Police
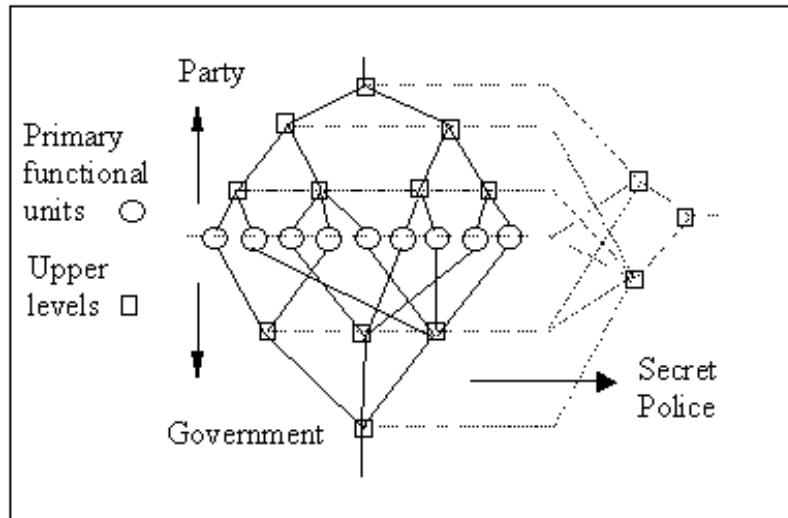
Figure 24.3. An approximation of the social connector price.

Let us note this pattern of double authoritarian control of technology and ideology, both converging in a single leader. While the Soviet system is dead, the pattern may resurface in any organization, national or transnational, oriented toward victory at any

In view of the redundant engineering of the society, the fall of the Soviet Empire came as a great surprise. There was no mass discontent, no organized opposition, and all dissidents were exiled or imprisoned. Neither Barbarians nor Vandals stormed the walls of the Kremlin. The system had no visible signs of internal tension, no hunger, riots, and no spontaneous drive for ethnic independence, except in the Baltic republics. With any dissent punished as a severe crime, the army under the party control, and civil war excluded, the USSR seemed to be in a deep pit of stability. No wonder, very few Russians could imagine that the collectivist system where even prices and salaries were fixed would ever collapse.

The rigidity of prices and salaries had its historical precedent, however, that could reveal a much finer similarity. One of the earliest examples is the Roman Empire under Emperor Diocletian (245-313) whose main goal was to cool down the Empire overheated by invasions of Barbarians, famine, riots, and exorbitant taxes. Diocletian fixed prices of commodities, wages, and cost of transportation by an edict, and some historians compared his rule with totalitarianism.

An elementary schoolteacher received 50 denarii a month per pupil, a teacher of arithmetic or shorthand 75, architecture 100, literature and geometry, 200, and rhetoric 250 (Africa, 1969, p. 435).

For comparison, in the former USSR all teachers of any subject were allotted same salary, the salaries of high school teachers, physicians, and lawyers were among the lowest, but the cost of public transportation and apartment rent was merely symbolic.

Diocletian pursued an absolute order, declaring the priority of the state over individual and using even a kind of secret police, but he did not go as far as to abolish private property. He was draining the resources of the population, while the Soviet system assumed that the government had to provide meager food, clothing, and housing for everybody, whether they produced anything of use or not.

The means to keep the pyramid frozen were the same in the later Rome and the USSR. As a remarkable parallel, Diocletian tied the *coloni,* the tenants of the landowners, to the land, turning them into serfs. Moreover, he expanded the serfdom to basic professions and made them hereditary. Stalin did the same by withdrawing the internal passports from the peasants and establishing control of the residence of every citizen so that the unwanted movement from one city to another in search of better life was prevented. Nobody could move around the country and get a job without passport.

In both Rome and Russia, the freezing worked only up to a point.

Yet, at most, his program arrested the decline for a time but did not reverse it. To shift the metaphor, although the patient rallied briefly under Diocletian's strong medicine, new complications were setting in, and the illness in the long run proved fatal (Brinton, 1967, Vol. 1, p. 135)

Diocletian is of interest for us because he introduced an innovative administrative pattern. He hierarchically divided the empire into four major parts, twelve subdivisions called dioceses, and 101 provinces. The novelty was that all the divisions were equal and none of them, even Italy, the birthplace of the empire and its metropolis, had a formal advantage over any other.

The Soviet Union had a great administrative imbalance, however: Moscow was the dominating metropolis and the rest of the country was a quasi-colony.

In frozen authoritarian systems the temperature is the highest at the top where not only all decisions are made but also a perpetual spectacle of power struggle, intrigues, rivalry, and perfidy is staged.

The frustration, limited to the ruling class, was intensified by the war in Afghanistan and the American Strategic Defense Initiative that could potentially make USA secure against a possible Soviet missile attack.

About five years before the change, the party, for whatever reason, started a campaign against corruption, which destabilized the ruling elite. The repression of dissidents antagonized the West. The industrial growth slowed down and the quality of goods was poor. The war in Afghanistan raised the body bag count.

Mikhail Gorbachev experimented with easing the monopoly of power and opening a crack in the door to free competition for power and ideas. In fact, as soon as the new Soviet leader made clear that freedom of thought might not be punished by prison, the internal rifts crisscrossed the political configuration.

The change of pattern occurred at the top of the pyramid of power, see Figure 24.4. Configuration **A** shows symbolically the two duplicate connectors of government and party.

Stage **I** was brought about by Gorbachev and consisted of several steps. He made peace in the Cold War, limited the terror of the State Security, and encouraged some civil liberties. By these measures Gorbachev antagonized the party apparatus (compare with the antagonizing effect of the government measures in France before the Revolution, Chapter 23, and the same effect two velvet revolutions in Chapter 13), who justly felt that they would be next, and the struggle ended in the removal of the party from power as an institution (stage I). The government remained in place, and since the elite (*nomenklatura*, i.e., list of top people with special entitlements and privileges, like the nobles and clergy in old France) had a double allegiance to both party and government, it could easily capture some key positions in the government. The mental pattern of both was power as the ultimate goal. To win meant to destroy the opponent.

From the very beginning of the historical transition Gorbachev and Yeltsin had been locked in a conflict of demonic proportions, which once again illustrates conflict as a bond couple. It is as difficult to separate sworn enemies as passionate lovers.

> Their personal battle had gone on for so long and contained so many seriocomic incidents that they seemed paired in eternal tension and dependence. Yin and Yang. Punch and Judy. (Remnick, 1993, p. 495)

The activities of the party were suspended. The party pyramid was thrown away like a scaffold after the completion of the building. The building without the scaffold, however, was on the verge of collapse. For the first time in over half a century, the apparatus of power accumulated internal tensions.

The main conflict was typically feudal: between the boss and his subordinate shown by double circles in Figure 24.4B. It was resolved by a very ingenious move which, unlike its

Medieval counterparts, involved neither violence nor violation of law. It was a velvet revolutions of a kind, compare with other two in Chapter 13, *Two velvet revolutions*. From the pattern view, it was a conflict in the connector.
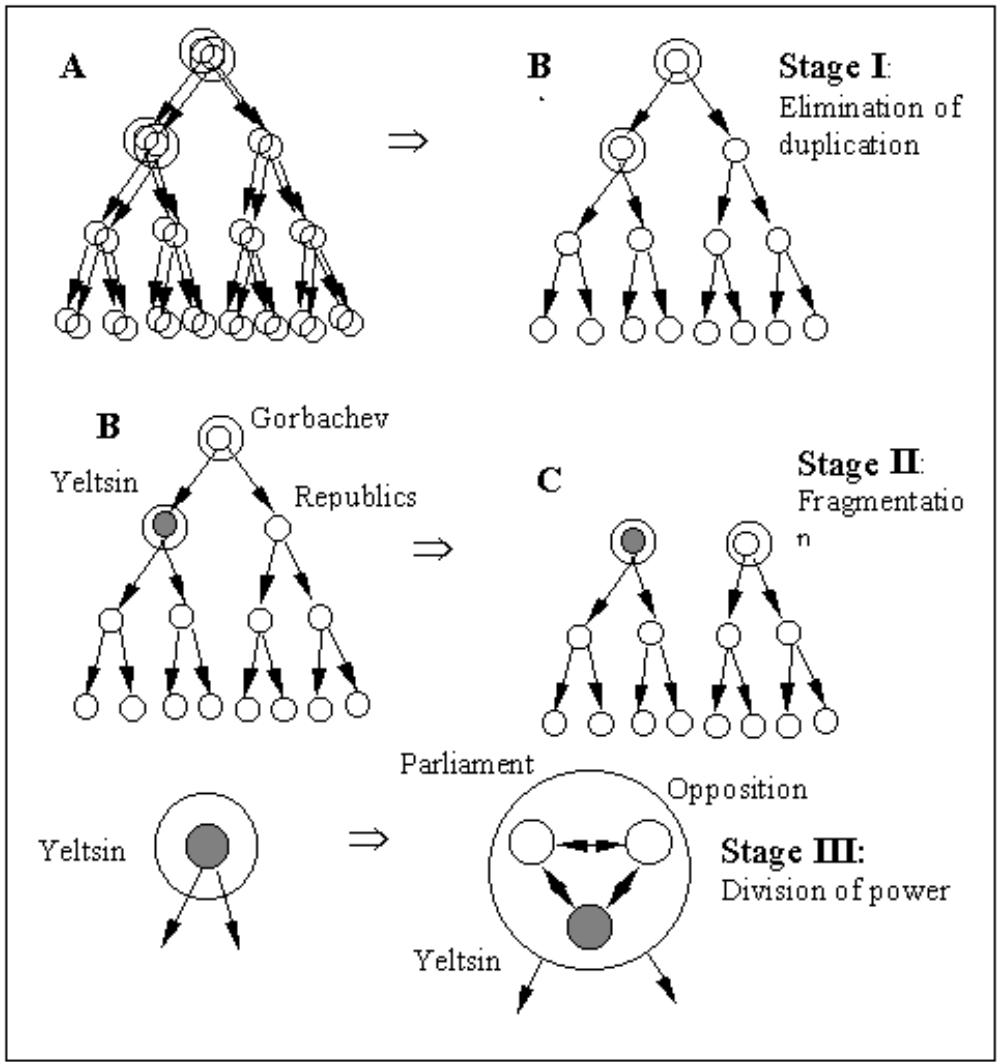

Figure 24.4. Self-beheading of an empire

Gorbachev was the leader of the USSR consisting of fifteen republics. Yeltsin was the leader of the dominant Russian republic to which the Moscow metropolis geographically

belonged. Formally, the Russian Republic and USSR were different hierarchical entities. In fact, the rival leaders were struggling for the same chair.

The Russian Republic within the Soviet Union, in spite of its domination, had a historically confused legal status. For a long time Russia *was* the Soviet Union with all the other republics as walking distance dominions independent *de jure* but not *de facto*. Only during the last decades of the USSR the Russian Republic was given a kind of nominal self-government.

The central fatal circumstance for the pattern of the collapse was that Moscow, the center of power, was the capital of both USSR and Russian Republic. Whoever was on top in Moscow, was on top within the borders of the USSR, and the essence of the conflict was competition for the capital city. The conflict was about Moscow.

The location of the American capital seems from this perspective very wisely chosen. The one thousand year long existence of the Eastern Roman Empire was, probably, made possible by the administrative reform of Diocletian that equalized the components of the empire. As we will see in Chapter 25, *The circuitry of Imperial China*, the same wisdom might have preserved the unity of China for thousands of years.

Yeltsin eliminated the "Gorbachev" generator from the configuration by arranging (probably, not anticipating all the consequences) the dissolution of the USSR (stage **II**). In the imperial Rome it would be equivalent of scraping the position of the Emperor and removing the Roman provinces from the empire. In American terms it would be equal to the unanimous vote of the Congress to dissolve the Union by eliminating the Federal Government and the Congress altogether.

On the one hand, the coup boosted Russia in the transition state in which all kinds of previously unthinkable actions were possible. On the other hand, in terms of pattern dynamics,

Yeltsin lowered the imaginary final state by showing the other leaders of republics an exciting picture of their own full power with nobody but God over their heads.

The Soviet Union was dominated by the Russians and after Stalin no other ethnicity was allowed to the very top. The dissolution of the USSR increased the number of top positions from one to the number of spin-offs. It was similar to splitting the Ma Bell into Baby Bells.

The self-beheading of the Soviet Union was originally agreed upon by the leaders of three Slavic republics—Russia, Ukraine, and Belarus. Unbelievably, it did not contradict the Constitution, which had a clear and fateful provision about the voluntary character of the Union. As far as we can judge, the voluntary character of the American Union is not that unambiguous.

In the large scale historical terms, the Bolshevik Revolution was a change of dynasty, while the Gorbachev-Yeltsin revolution finally accomplished the transformation of Russia into democracy, however imperfect.

Gorbachev found himself a president without the country and resigned. This elegant transformation, driven by the quest for power, was completed without a shot.

The dissolution of the Soviet Union eased the competition for power because it gave uncontested power to fourteen more leaders, who used it in different ways. Some resurrected the totalitarian pattern, others turned to nationalist or pragmatic democracies. This makes a big difference from the story of Abel and Cain, probably, because there was no dynastic claims between the leaders of the republics, who had, with very few exceptions (Armenia and Azerbaijan, for example) nothing to argue about, and, therefore, no boxing ring was needed. The transformation did not bring peace to the new Russia because some of her ethnic provinces, like Chechnya, claimed little pyramids for themselves. This time, however, the land was disputed by nested dolls and not by neighbors.

An alternative scenario would be an order to the Army to restore order and to reinforce the rafters of the pyramid, which was either impossible or unacceptable for Mikhail Gorbachev. The transition barrier toward total internal bloodshed was too high for him. His indifference and weakness meant that the upper structural elements of the system could be treated as neutral bonds and they were disassembled quietly with a wrench and not a sledgehammer.

The pattern of the cutting the top of the pyramid worked all the way down through the floors of the building, and following the same pattern, the system of business management was split along territories and industries, with many of former *nomenklatura* becoming mini-czars in their areas.

Russia, the biggest chunk of the former Soviet Union, stepped on a new path with great hopes for mass prosperity but without the tradition of the rule of law. The reforms came from the top, as it was after the revolution of 1905. Free elections changed the political system, but the pattern of thinking in terms of pyramid remained.

That certainly promised a bumpy ride. Immediately, Yeltsin, the man at the top found himself fighting opposition, being unable to destroy it, similar to the position of an American president in a conflict with the Congress. In Figure 24.4, we symbolize stage **III** by the transition from a single unopposed leader to several competing sides locked up in a conflict, president and parliament among them.

The social pyramid in Russia is gone but it sits in the national memory as a persistent pattern, catalyzing new attempts to restore it. Nevertheless, the democratic process goes on.

To compare with ancient Rome, both empires were melted by a hot external source. For Rome it was the invaders, for USSR it was the pressure of the West waging the Cold War and waving the nuclear stick and the technological carrot. In both, the decisive transformation started

at the top. In both the subversive carriers of new ideas (Christians in Rome, dissidents in Russia) joined the governments in the end.

Next we would like to compare Russia and USA with China, the biggest and oldest authoritarian system ever known.

25. The circuitry of imperial China

In Chapter 7, *The King and the pear*, we have already touched upon some roots of past tension between China and the West. Here we are interested in some internal patterns of old imperial China, and as everywhere, we emphasize the tentative and abstract character of our constructs. They should be regarded as an exercise in pattern thinking and not in history of China, which should be left to professional historians. Our almost exclusive source here is Charles O. Hucker (1975) where we found some interesting diagrams.

History of China is long, rich, and complicated. It is traditionally divided into three periods: Earlier Empire, Later Empire, and modernity. China knew alternating periods of fragmentation and unification, numerous wars, some victorious, some lost, as well as occupation and liberation. Table 25.1 presents, for reference, an approximate sequence of Chinese dynasties.

Table 25-1. **An approximate chronology of Chinese dynasties**

2000 B.C	Hsia
1000	Chou
500	Spring and Autumn Period
	Period of Warring states
	Ch'in

The Early Empire, 206 B.C.-A.D. 960

200	Han
A.D.	Hsin
	Later Han
200	Three Kingdoms
300	Chin
	North-South Division
	(Sixteen Kingdoms)
600	Sui
	T'ang
900	Five Dynasties and Ten Kingdoms

The Later Empire, 960-1850

1000	Sung
	Northern Conquest dynasties
1200	Southern Sung
	Yüan
1400	Ming
	Ch'ing
1900	Republic of China, now in Taiwan
1949	People's Republic of China

With all its complexity, Chinese history emanates a strongly consistent spirit.

For most of its life span China was a vast unified empire which in modern language could be called an absolute totalitarian state. The term "totalitarian" is usually associated with ideological repression and deprivation but it can also be a welfare state where the prosperity of

all those who are considered good citizens is the goal of the government. That was one of the ideas of Confucianism, the most influential traditional ideology of China.

If we wanted to look for a polar opposite to Marxism, with its idea of class struggle, Confucianism, with its idea of harmony and the Middle Way, would be the best candidate. Nevertheless there is a curious parallel between the officially proclaimed principles of the Soviet totalitarian state and the Chinese Imperial doctrine of the Chou dynasty (1122-256 B.C.). Confucius (551-479 B.C), who lived in the Eastern Chou period (770-256 B.C.), proclaimed himself the carrier of the old traditions of Chou, part of which was the doctrine of the Mandate of Heaven:

> The scope of government was all-encompassing. As Sons of Heaven, the rulers of China in Chou and later times were considered wholly responsible for whatever happened "under Heaven." It followed that peace and order could not be their sole concern. Indeed, even if the country prospered, their duty was not discharged; morality had to be ensured as well. Thus what modern Westerners think of as welfare-state ideas were commonly preached, accepted, and put into practice in Chou China. The ruler was administrator, military leader, judge, manager of the economy, priest, educator, and moral exemplar. His responsibility was total. Accordingly, his authority had to be unlimited; and the Chinese polity came to be organized in such a way that the ruler's authority was totalitarian in practice, in the sense that no aspect of life was considered immune to his control (Hucker, 1975, p. 56).

This quotation, as well as its representation in Figure 25.1, need very little change to perform the similarity transformation from old China to the Soviet system.
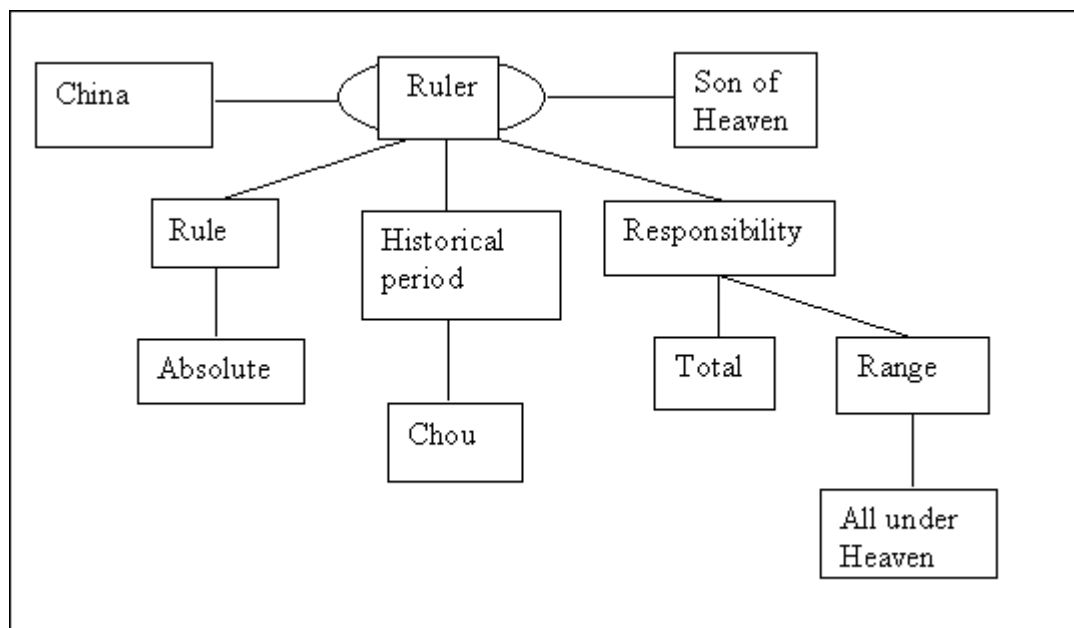
Figure 25.1. A totalitarian configuration in Chou China

Sons of Heaven	⇒	Heirs of Marx and Lenin.
China	⇒	Russia
Chou	⇒	Soviet
Under Heaven	⇒	In the world

In pattern terms, the followers of Confucius intended to increase the cohesion, solidity, and functionality of the society by cultivating reciprocal positive bonds:

Five Key relationships	Appropriate virtues
father-son	filial piety
ruler-subject	loyalty
brother-brother	brotherliness
husband-wife	love and obedience
friend-friend	faithfulness

This template was only slightly deformed in Russia. The official virtues proclaimed by the Communist Party were under the influence of the slogans of the French Revolution (*Liberté, Fraternité, Egalité*), but the obedience to the Party, as well as the intolerance toward enemies were equally emphasized. Personal friendship and even filial piety were expected to take the back seat behind loyalty to the Party. As the Cultural Revolution in China demonstrated, the same correction was made in Maoist China.

The list of Confucian virtues might present a problem for a loyal Chinese because of a possible conflict between, say, loyalty to family and loyalty to the ruler. We have some reason to believe that family ties often prevailed (Bloodworth, 1967). And yet we know that terrible situations when a choice had to be made were typical not only for both cultures but for practically all dictatorial regimes. The lack of loyalty to the ruler might mean death.

We are tempted to recur to a "patternization"—being fully aware of its ultimate vulgarization—of the classical Chinese philosophy.

Confucianism was, probably, a utopia, and it was complemented in Chinese philosophy by two other intellectual concepts: Taoism, which we would simplistically characterize as cultivating neutral social bonds, and Legalism, which meant maintaining order through the law, under the threat of punishment, i.e., by enforcing negative bonds. The legalist idea asserted the primate of the state interests over the individual ones as consequence of the inborn faultiness of humans.

We can, therefore, divide all basic social paradigms into three categories:

1. Cultivation of positive social bonds (Confucianism, nationalism, Communism, Socialism, fundamentalism).

2. Cultivation of neutral bonds (Taoism, escapism, individualism, anarchism).

3. Enforcement of negative bonds (Legalism, despotism, totalitarianism, slavery).

In practice, the three concepts could be compared with the three basic colors that being mixed in varying proportions produce all the other colors and hues. They can be found in all state doctrines in different proportions.

While Confucianism regarded people as basically good, Legalism saw them as basically bad. In China, Confucianism in pure form turned to be impractical. After a period of cruel Legalism ending around 200 B.C., China arrived at a synthesis of both: the law was severe, but, supposedly, based on the principles of Confucius.

Sociologists may notice how our osteological approach differs from the well known expressive analysis of Chinese ideology by Max Weber (1964).

The former Soviet society relied on both the law and the standard of thinking, unknowingly imitating the Chinese pattern of mixed Legalism and Confucianism. Revolutionary France pronounced patriotism a national faith. Europe, with its competitive geopolitics, has always had a traditional glue of positive bonds in the form of nationalism. American society does not seem to care much about ideology, except individual freedom.

We can certainly see elements of legalism, without its philosophical generalizations, in the Western idea of law and order. In America it struggles with the individual, corporate, partisan, ethnic, feminist, adolescent, and scores of other visions of order. We would half-seriously characterize the American society, with its reliance on law, as Legalist-Taoist—a somewhat stressed combination. To ease the stress, the society lets the lawyers fight legalism with its own weapon.

The Imperial Chinese pattern of government was designed to maintain the highest possible order. The goal was achieved by increasing the number of bonds in the connector, i.e., the same way as in the Soviet system.

> Thereafter [after Han period] all imperial governments resembled a pyramid, with the emperor at the apex and groups of ever more numerous agencies in central, regional, and local strata under him, each level of the pyramid having three faces—one for general administration, one for military command, and one for censorial surveillance. It would be grossly misleading to suggest that there were clear divisions of governmental powers, since all power emanated from the emperor; but there was a relatively clear differentiation of functional responsibilities (Hucker, 1975, p. 149).

The three-faced pyramid is remarkably similar to the triple pyramid of the Soviet system. In this tree-like hierarchy of government, for example, in the Former Han times, Figure 25.2, the commanders had full power over their counties and the control of the court ended one level up above their heads with the circuit intendants who were agents of the court. Note that the circuits were the units of the central government, not local one. The local power started below the double line, was distributed geographically, and had a tree-like connector.

In the T'ang period, the structure of government became closer to a symmetrical pyramid, Figure 25.3. The local share of power was limited because of the large number of local units and, therefore, their small size.
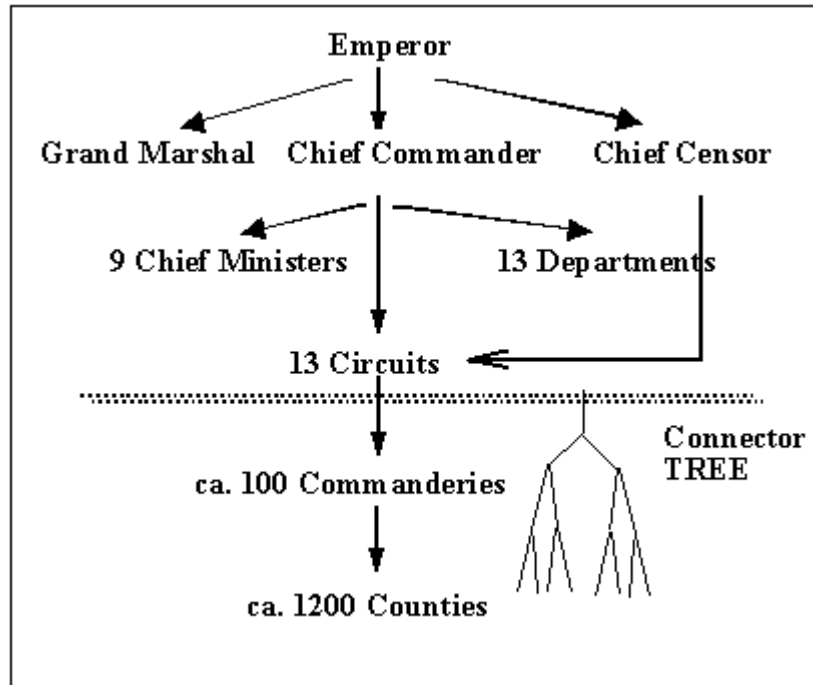
Figure 25.2. Chinese government on former Han times

By the end of the Early Empire, large regional rulers, similar to governors, evolved from circuit intendants. The borderline between the central and the local governments moved up one step, to the double dotted line (Figure 25.3), and the circuit intendants became powerful governors. As result, the empire fragmented during the time of "Five Dynasties in the North and Ten Kingdoms in the South."

The intermediary zone between prefectures and the central government—the trouble zone from which regional governors and warlords had repeatedly gained autonomy during the early imperial age—was kept under firm control by the later dynasties. The founder of the Sung dynasty, keenly aware of the danger of separatism, temporarily eliminated all intermediary-level agencies and established direct lines of responsibility between prefectures and the central government (Hucker, 1975, p. 311).

The Later Imperial China did not have the multilevel hierarchical connector of the Russian system in which the second and third level from the top could accumulate large power. The distance between the court and the local units was made as short as possible, but it was bridged by the same three parallel systems: general administration, censorial surveillance over complaints and violations, and military control.
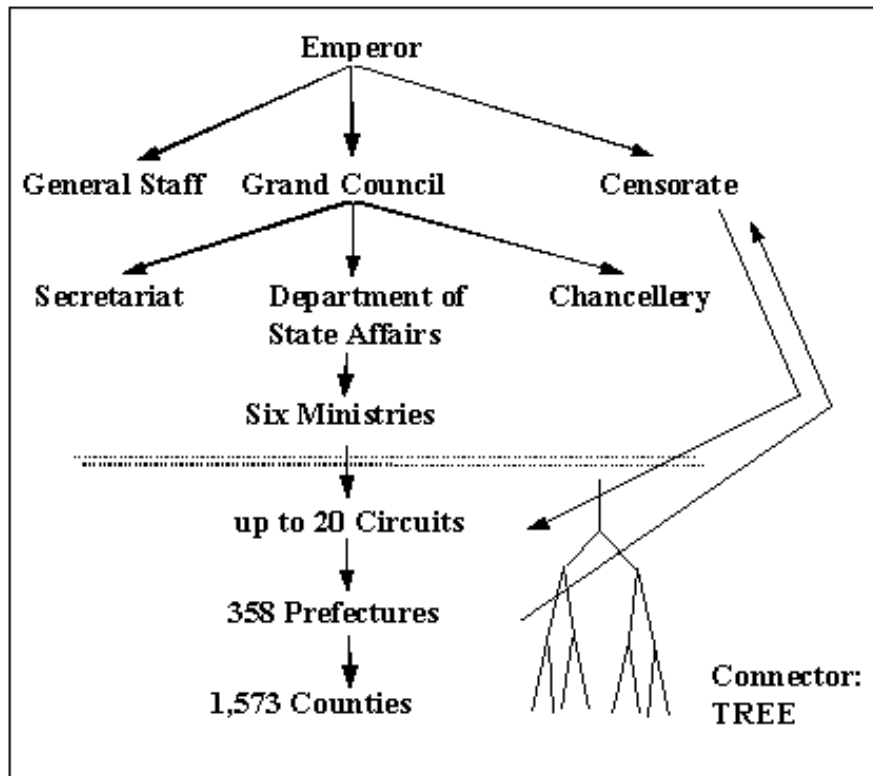
Figure 25.3. Government of China in T'ang times

The main obsession of the Chinese concept of the government was the reliability of the system and the control over the reciprocity of the obligations of the ruler and his subjects, which makes a cardinal difference from the Soviet or Roman systems of domination. The Chinese system was designed not so much to maintain the negative bonds as to weed them out and

alleviate stress—a very natural intent of the owner with the Mandate of Heaven to keep his household in good shape.

The system of censorate was, ideally, independent from other government agencies and worked both upstream and downstream. Somewhere in the middle of the Soviet period, an attempt to create a "censorate" (Agency of State Control) was made in USSR.

The China of Sung around 1000, had the structure of government schematically presented in Figure 25.4.
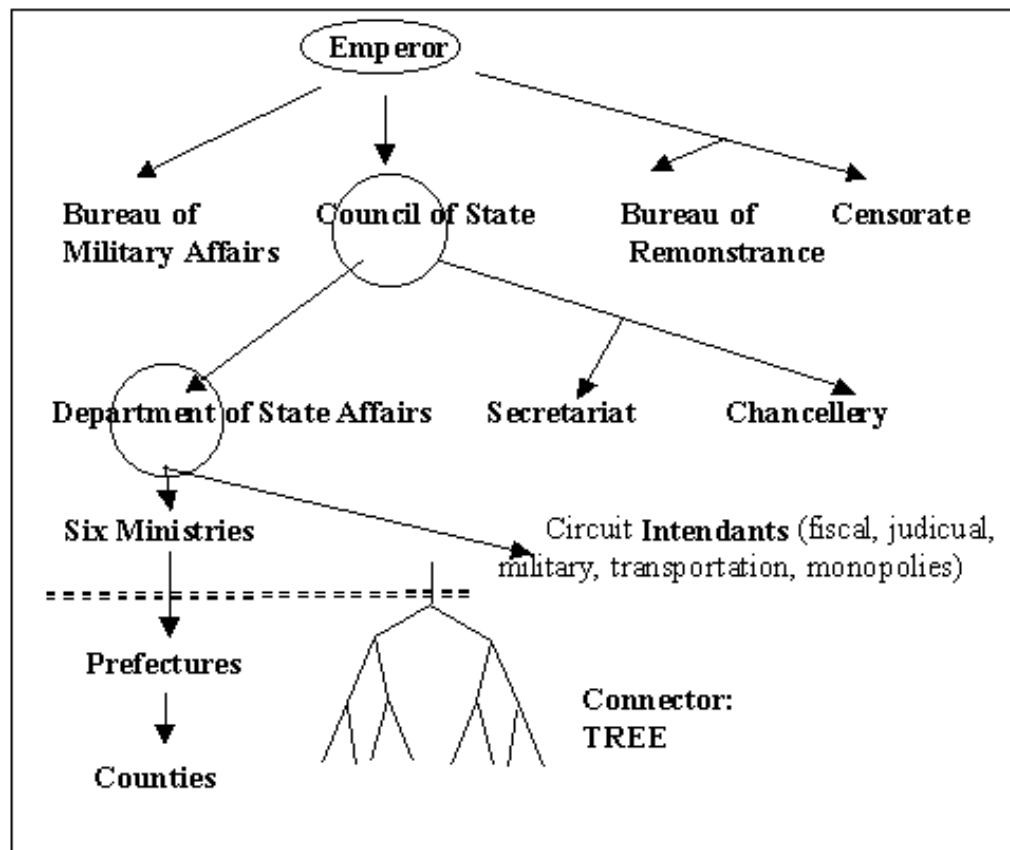
Figure 25.4. System of Chinese government in Sung times

The system of circuit intendants, functionally different and territorially overlapping in different ways, was employed so that no one could monopolize power. The territorial units,

prefectures and counties, were approximately equal in size and placed under the foot of an elaborate and heavy government structure, not exactly pyramidal.

In the Ming period, around 1400, the same goal was achieved by a more symmetrical triple system of military, administrative, and surveillance management, see Figure 25.5. The connector of the enormous government, however, looks overwhelmingly complex. It even contains the ominous cycles that weaken the system. But there is a source of strength, too.

The Ming China had thirteen provinces and two metropolitan areas. The administrative division of the later imperial China displayed at the lowest levels of the governmental pyramid, so that the distance between the imperial government and local events was minimal. The Chinese connector was not pyramidal, and there were no leaders of the next down level.

After this superficial description of the old Chinese system of government it is reasonable to compare it with the Soviet system, which had fifteen republics—a number comparable to the thirteen Chinese provinces.

The division of USSR into Union Republics started at the top level of the pyramid, Figure 25.6. It was the pattern inherited from the old Russia with governors appointed by the czar. The pyramid was five levels high and much more complex than shown. At every level there was local government that had all the power over the lower levels, and it was duplicated by party offices. It was typical, therefore, for every boss to be a big or little czar. Stunning examples of the imperial life style of the two upper levels of the Soviet pyramid, including collection of tribute and the royal hunt, in one of which the last Central Asian tiger was said to be killed by Zahir Shah, the visiting king of Afghanistan, are collected by David Remnik (1993).
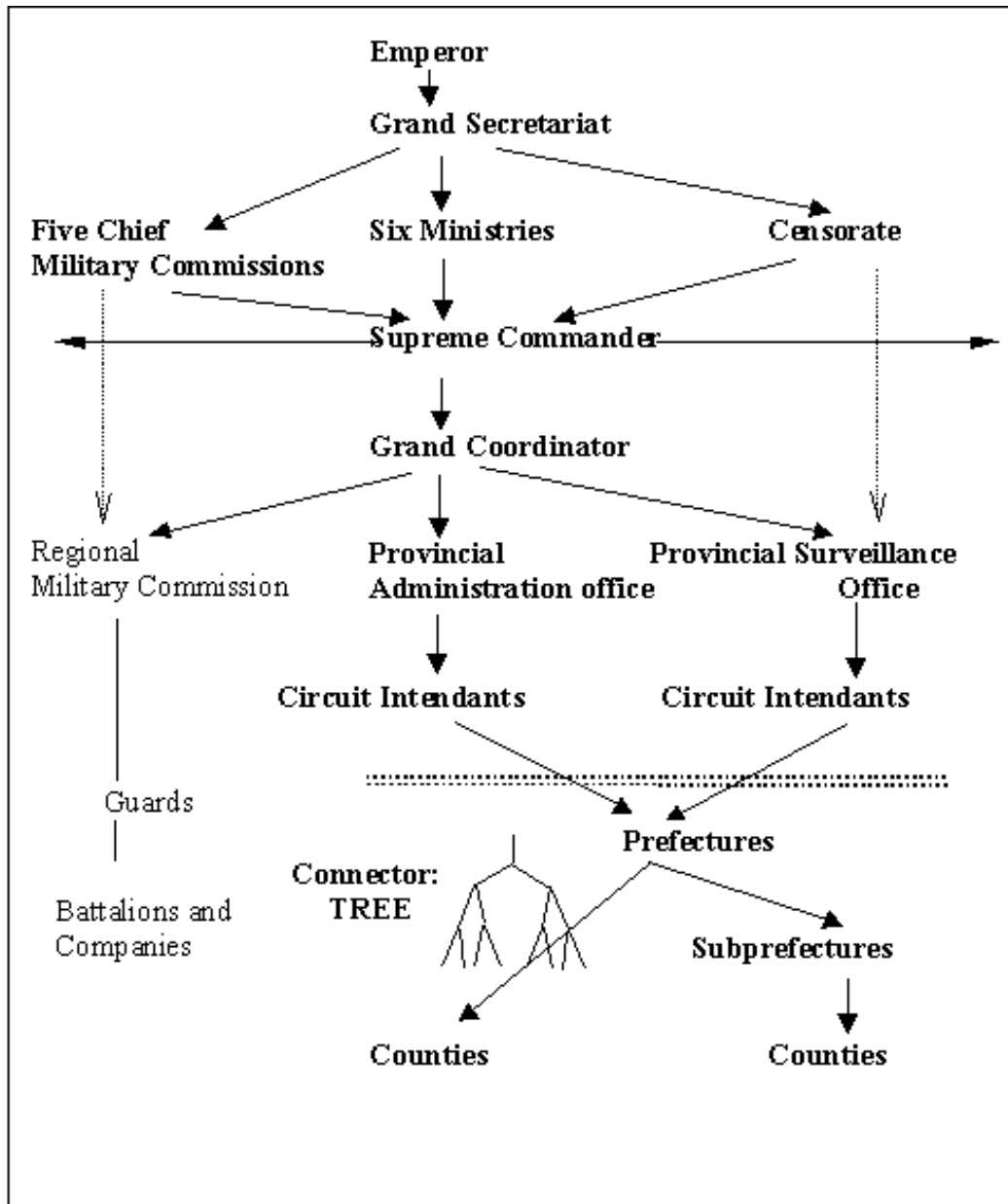
Figure 25.5. System of Chinese government in Ming time

Like the imperial China and Diocletian's Rome, the USSR was a conglomerate of nominally equal republics, but the dominant Russian Republic was much bigger than the other fourteen combined and the balance of power was skewed. What happened in Russia was exactly

what the Chinese emperors wanted to prevent: the strong leader of the strong middle unit revolted against the weak "Emperor."

To solve the typically Russian vertical conflict, see Figure 24.1, required an authority higher than the leader of the Soviet Union, which was nowhere to be found.

Dozens of largest territorial units in Russia of the czars were comparable in resources. Peter I and subsequent emperors could not anticipate Lenin and Yeltsin, however. The former added yet another level, the republics, to the pyramid, and they used the fatal imbalance to undo the empire.

Looking at the fate of USSR, we see a historical irony: the dominant role of ethnic Russia was the main source of the stability of the Soviet era. The same factor was the main cause of the collapse of the empire.
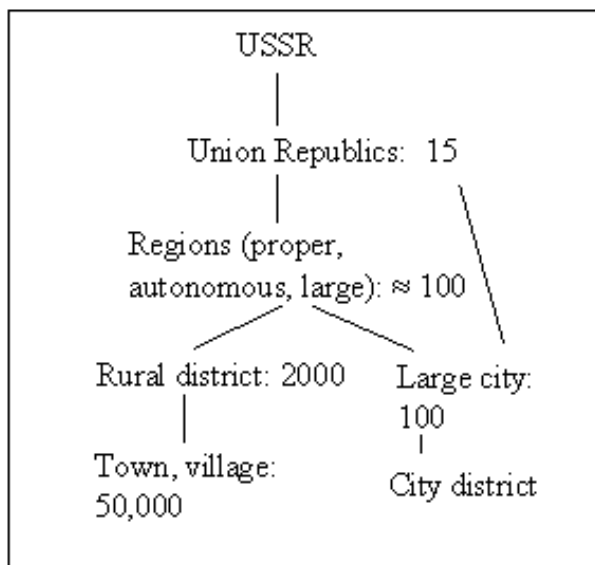
Figure 25.6 . Administrative structure of USSR. The numbers are approximate

To compare, the events in former Yugoslavia, although different in nature, were stimulated by the same imbalance between the industrially developed and densely populated Serbia and other less developed or less Panslavic regions.

History is full of irony. Once born, patterns do not die, which follows from the very nature of patterns as abstract mathematical constructs. While the course of history is irreversible and configurations never repeat themselves, patterns might come back because they populate a

relatively small combinatorial space. The choice of historical and social patterns is, apparently, limited.

Fatalistic platitudes, however, would not help us recognize when one pattern is ripe to undergo a metamorphosis and what is going to crawl out of its dead skin. There must be some basics of pattern transformations independent from their particular structure, and if so, we could use them for incubating the desired patterns and refrigerating the unwanted ones.

If only we all wanted the same...

26. Order—chaos, heat—cold.

In this chapter we return to such aspects of pattern dynamics as energy, temperature, heat, work, and other parameters unrelated to structure. We have already encountered them in Chapter 15, *Invisible walls of events*. The problem is whether the use of the thermodynamic terminology to something as immaterial as patterns is legitimate.

In Chapter 20, *Probability and energy*, we drew a parallel between probability and energy of patterns. We borrowed it from statistical mechanics, an area of mathematics applicable not only to physical but to abstract systems as well. In all such systems we have a very large number of independent and interacting microscopic entities, each with its own tiny value of a certain changing parameter. Let us call it energy. The total energy of the ensemble is the sum of all its microscopic values. The entities exchange energy at very fast random interactions.

Examples of large collections of microscopic entities are molecules, insects in swarms and colonies, and humans exchanging money and work in national and global economy.

Statistical mechanics was never designed either of them, and not even for real molecules but for highly idealized and non-existent objects. Spherical particles of molecules of gas moving chaotically and exchanging energy at each collision are pretty close to this model. Life and society do not maintain total energy constant. Neither are they in the equilibrium required for the statistical model. Nevertheless, we can accept the classical thermodynamics as a crude approximation, especially if we never lose from sight the non-equilibrium properties of real systems, the slow pace of their change, and the typical for complex systems phenomena pf memory and locality of change.

The idea of the statistical approach to physical systems was to calculate macroscopically measurable values of energy, pressure, and other parameters not by following the position, velocity, and mass of each particle and then adding the individual values, but from statistical averages over the entire crowd.

Everywhere throughout this book, when we seem to draw analogies between the behavior of human society and that of physical or chemical objects, we in fact try to apply neither physics nor chemistry but some very general mathematical concepts, already tested on molecules, to "human molecules.". We do not derive social energy from physical one, as we do not derive a human from an ape, but regard them both coming from a common source. We must make sure, however, that those concepts do really apply, and this is where we encounter multiple problems. Thermodynamics of individual and social behavior is underdeveloped.

Let us take probability, for example. To speak about probabilities, we need a reproducible system in which a large—the larger the better—number of events with different outcomes can be observed and counted.

Probability of a certain outcome shows how often it occurs as compared with other outcomes. For example, if the event is tossing a coin, then in a very large number of tosses heads and tails fall out equally often, i.e., their probabilities are close to 0.5. Probabilities vary between zero and one. For example, the probability that the coin falls flat is 1, which means that no matter what, either heads or tails always come out. This is not so simple when tossing a coin over sand where it can not only fall flat but wedge into the sand. We also cannot rely on a bent or tampered with coin. We cannot use a rigged coin in statistics, but humans in the small leadership groups, which are usually responsible for historical decisions, are always bent on something, and, worst of all, like Louis XIV, sometimes fall neither heads nor tails but on edge.

When we attribute a probability to a bond couple in quantitative applications of pattern theory such as image processing, the probabilities can be calculated by observing a large number of images. One of the oldest examples is the analysis of the frequency with which a certain word follows another word in the text. To obtain these numbers, many chunks of text should be statistically analyzed and to speak about probability is perfectly permissible.

In pattern history we deal with unique events that can never be repeated. Strictly speaking, there is no place for probabilities, unless we have statistical averages, and often we indeed have them. The statistics of divorce, one-parent families, and domestic violence, taken over a large population at different moments in time, tell us about the average (i.e., regular) strength of family bonds. We feel uncomfortable, however, speaking about the strength of the bond between the king and his subjects in terms of probability. Yet the kings and dictators themselves had no qualms about that and kept a mental index of probability of the associate's betrayal, taking preventive measures if the index spiked.

Although totally unscientific, the likelihood assessment is widely used in everyday life even without any statistics and with events that have not yet happened.

Of course, we could keep silence about probabilities and talk only about the strength of bonds, as historians do, but with the kings and their subjects, as well as with presidents and democracies, *chances are* (here the probability creeps in) that our predictions will be proved wrong. Nevertheless, when we have a certain pattern of past behavior, based on an extensive record, there is a *good chance* the prediction will come true. That was certainly the case when political analysts had predicted before the first term elections that Bill Clinton as president could flip on his words.

Strength of any physical bond can be expressed through the probability of its breaking under stress. Usually the material strength is expressed in the minimal load that breaks it. We can say that a string holds 100 lb, but this is also a statistical value: some strings of the same brand may be stronger and some weaker, with certain *probability*: larger deviations are less probable.

We cannot escape probabilities even using the tempting euphemism of bond strength. Nevertheless, without any intent to undermine the foundations of science, we can make a wild conjecture that the strength of the bond couple is a more general and universal concept than probability of its breakup.

We must acknowledge that we are at the starting point of the evolution of our understanding how social patterns develop and we cannot satisfy even most liberal requirements of scientific theory. We have to remind again that we are not developing a sociological theory. What we are trying to do is to find a way to speak about society in terms equally applicable to any natural phenomenon. What to responsibly say in this language is up to professionals.

It may seem that our vacillation and uncertainty on the subject of pattern energy would sharply contrast with the rigor of physics. It turns out that the physicists had their share of confusion, too. In the following quotations from a reference book on physics, the italics are ours.

> Energy is a certain abstract scalar [i.e., having no direction] quantity that an object (either matter or wave) is said to possess**. *It is not something that is directly observable, although in certain cases, the behavior of the object possessing a particular amount of energy can be observed and the energy inferred.* The usefulness of the concept comes from the fact that total energy cannot be eliminated or created in the world, rather energy must be conserved (Walker, 1981, p. 287).

Certainly, everything must be crystal clear about heat: we heat up and cool down objects every day. And yet:

> In more complex processes, which may involve mechanical as well as thermal interaction, the heat transferred is more difficult to identify. *In fact, much of the history of thermodynamics concerns the slow evolution of clear concepts of heat, energy, and entropy, and of the distinctions between them. In the resulting science of thermodynamics heat is defined and measured indirectly in terms of the objectively measurable quantities energy and mechanical work* (Walker, 1981, p. 382).

Not only that, but statistical physics feels uncomfortable about macroscopic values, too. They are true only with a certain probability of error. If we calculate the pressure of gas in a corked bottle from its temperature, we do not have a multitude of bottles with gas. This is why the physicist says that the pressure is an average over many imaginary bottles identical with this particular one. Could we say "counterfactual" bottles?

The property of interest is computed by determining its average value, taken over a suitable ensemble of similarly prepared systems.

To construct an ensemble for a particular calculation, we consider an arbitrarily large number of independent replicas of the system, which satisfy the same macroscopic constraints as the system but may differ in their microscopic states (Walker, 1981, p. 953)

We used a similar cop-out when presented our pattern history as related to an imaginary planet like ours. Indeed, since we are not historians, we say that our England, France, Russia, and China are to be found as independent replicas on other planets similar to our Earth. This trick is not as shameless as it may seem. In fact, the sociologist Peter Blau (1980), illustrated his concept of sociological structure with the help of an imaginary society on the planet Stellar 8R populated by the Aytars that come in two colors, blue and green, vary in height from ten to thirty inches, and have neither sex nor age. Nevertheless, these simple beings developed an amazing social complexity.

And so we decide to simply cut the Gordean knot, use probability and strength interchangeably, and do what we intuitively consider right. Let us see what comes out of this possible abuse of mathematics.

The next problem is that in physics the distinction between two forms of energy, heat and work, is cardinal.

Work is the transfer of energy from one object to another by a force from one on the other when that second object is displaced by the force. Often the nature of the first object need not be specified if the force doing the work is known. *For example, one can push a box, and the force performing the work is the pushing that the box experiences. The work can be calculated without knowing anything about the person pushing.* In general, the work done on an object can be calculated from knowledge of either the applied force or the energy changes involved (Walker, 1981, p. 287).

In real life, as well as in history, the knowledge of who is trying to push a box is most essential.

What is the social energy then: pattern work, heat, or both? This is how we can describe them in pattern terms.

Heat is chaotic energy which rattles all bonds indiscriminately and tests their strength. In times of war and revolution, or in a state of agitation, people act as they would not under normal circumstances.

The concept of work has a strong analogy with construction work. It is done according to a certain plan or program, and it does what no heat can do on its own: it builds. Work is always applied to particular structural fragments: a bond is closed here, opened there. The individual development of a human being from egg and sperm is a lot of work and no chaos. Social construction, too, needs a certain mechanism, which is what the society is all about. In times of social chaos this machine functions with deviations from its expected performance and can break down. In pattern terms, we say that the rules of regularity change and we have to look for a new pattern and a new template.

The similarity between society and machine is the cyclical character of its function. Like the crankshaft of an engine, it makes a daily turn and comes to the almost the same state next morning. In a sense, the pattern of any technology is borrowed from the design of our solar system: the machine does it over and over again. The difference is that the machine needs a source of energy and the universe goes on its own.

Work organizes society and keeps it in order. It is much more difficult to do complex job a state of agitation or under barrage of irritating impulses. The negative bonds require complex and organized efforts to stay in lock. We believe that the energy that carries the society over the

transition barrier has a large chaotic element. It is closer to heat than to work. On the contrary, the long-time systematic trends of society, like the movement of the American frontier westward, when the railroad system grew, the industrialization of England, urbanization, growth of working class, and the subsequent improvement of its miserable conditions, were driven by systematic work at a low degree of chaos and along conscious patterns. In the process, some bond couples are locked, some broken, and some made neutral. Along the way, the degree of chaos is diminished by regulations.

Figure 26.1 helps explain what we mean. We start with a simple triangular pattern (it could be a love triangle), with three generators and three positive bonds between them. To show different strength of the bonds, we use lines of different thickness. Heat makes all of them weaker (thinner). Cold, on the contrary, makes them stronger (thicker).

Work is always selective: we break or form bonds not by creating a psychotic atmosphere but patiently working one bond at a time, according to some plans, and using social mechanisms. During this process, politicians can counteract the action of other politicians and working on the same nut with two wrenches in opposite directions.

In times of war, psychosis is exactly what breaks the internal bonds of the opponent. Abstract heat and not work is the weapon of terrorism. In 2001, the terrorists clearly wanted to trigger national psychosis and break down the mechanism of normal life. The US counterattack in Afghanistan used the relentless bombardment to break down the cohesion of the Taliban.
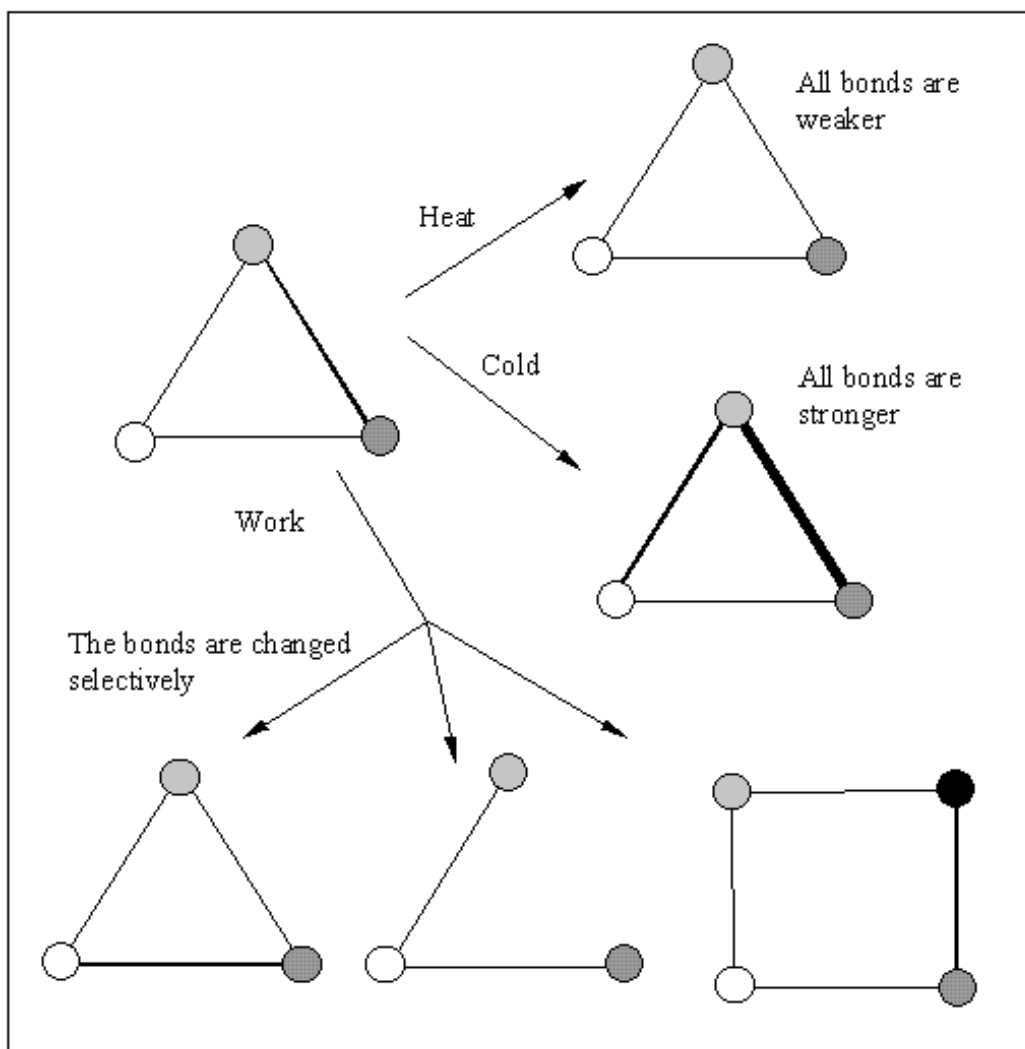
Figure 26.1. Social heat and social work

Friedrich Nietzsche firmly imprinted humanities with the famous dichotomy between two contrasting perceptions of social and cultural values, Apollonian and Dionysian, which we quote

in the terse transcription of Ruth Benedict because the exuberant language of Nietzsche allows for different interpretations:

> The Dionysian pursues them [the values of existence] through 'the annihilation of the ordinary bounds and limits of existence'... The Apollonian ... keeps the middle of the road, stays within the known map, does not meddle with disruptive psychological states (Benedict, 1959).

To complement this, here is the essence of the subject as rendered by the editors of the newest edition of Nietzsche:

> 'Apollo' embodies the drive toward distinction, discreteness and individuality, toward the drawing and respecting of boundaries and limits; he teaches an ethic of moderation and self-control. ... The Dionysiac is the drive towards the transgression of limits, the dissolution of boundaries, the destruction of individuality, and excess (Nietzsche, 1999, page xi).

In terms of Nietzsche's Apollonian-Dionysian dichotomy, we can call pattern work Apollonian and pattern heat Dionysian. If social thermodynamics is to be developed, Nietzsche will be remembered as its founder.

In a more or less stable—Apollonian—world, some probabilities should be close to one and some others close to zero. For example, in our real world the probability that our mail with bills and checks will be delivered on time and to the right address is pretty close to 1, while the probability that an asteroid collides with our planet tomorrow is rather low. The probability of the Earth being hit by an unknown near-earth-object 1km or greater in diameter within a year, according to some estimations, is roughly one in 100,000. If two airplanes strike two skyscrapers within two hours, there is no place to chance and there must be a lot of careful work behind.

Speaking about physical bonds, the probability that we will lose a car wheel while driving tomorrow is negligible, and so is the probability that the car door will form such a strong

bond with the door frame that we will not be able to open it. Yet there is a non-negligible probability of an accident tomorrow in which both improbable events can happen. We decrease this probability by increasing our attention while driving, which in a dense traffic or poor weather can be an exhaustive work, as we all understand without any physics. By driving carefully, we in fact (from the pattern view) increase the strength of the bond between the wheel and the car and keep the bond between the door edge and the body neutral. We increase the probability of the accident by reckless—Dionysian—driving and maximize it by literally Dionysian drinking.

The Nietzschean thermodynamics is an interesting subject in itself, and the original text gives a lot of material to a pattern sociologist, but we have to move on.

We could say that work creates order out of chaos. This could be its convenient definition if not for one circumstance. Order can be created by decreasing temperature, too. Therefore, we should specify that work is capable of creating order at constant temperature.

In thermodynamics this relation between work and order is expressed by one of the most important, though simple, relations:

Work spent = Temperature × Created order

This means that temperature is, actually, the price of order: the higher the temperature, the more work is needed to create a certain order, keep all negative bonds in place, and repair the broken bonds of all kind. The scientific term for created order is the decrease of entropy.

A strong repressive government, controlling the army, is always capable to suppress riots of unarmed masses. A social revolution has a good chance to win when the government is weak or separated from the army. The latter could be the case during an unpopular war.

The state of war was often used by both dictators and democracies to freeze the society, limit the degree of freedom of speech and movement, control consumption, etc. This may seem to contradict our interpretation of war as a heater for society. What we mean is that the government needs the martial law to cool down the military machine so that it could function reliably and win the war. Yet these measures are effective only when the war is popular. The propaganda links the desirable victory with the need to sacrifice the benefits of peace. During the unpopular Vietnam War even harsh measures could not maintain the link between the war and the justification of sacrifices. The plight of the ethnic Japanese in USA during WWII drew little attention because the war was popular.

Since the Industrial Revolution, our civilization has been driven by our ability to burn fuel and to convert the chaotic energy of heat into organized forms of energy capable of performing work. This is done by using heat engines, always at a price: only a part of the energy of the fuel can be converted into work and the rest is wasted. The use of energy in the form of heat, cold, mechanical work, electricity, and food is the ultimate source of social life. Limited to food as the only source of energy, the society can revert to its tribal forms.

We cannot say whether social energy is conserved or not because we cannot measure it. What we borrow from physics is the consequence of the principle of conservation. Suppose we have two systems that communicate only with each other.

They are presented in Figure 24.2 by squares of different intensity of gray color: the darker, the more energy. If they initially have different energy and are isolated from the rest of the world, the principle of conservation says is that it is impossible for both of them to increase or decrease energy simultaneously because it would change the total quantity and violate the conservation principle. The only possible change for them to equalize their separate energies. This principle, however, does not tell us that this would indeed always happen within certain time. We can place side by side a box of explosives (high energy) a box of sand (low energy), and even a lighter, but nothing will happen without human intent. There is a gap in classical physics because life and society had never been its objects.

Figure 26.2. Possible and impossible spontaneous changes

Naturally, any change which is spontaneously impossible in Figure 26.2 is possible if we have certain tools and a source of energy which can be converted into work, for example, heaters and refrigerators. Thus, we can convert **B** into **A** by placing the refrigerator in the wall between chambers so that it heats one chamber and cools the other.

Not all systems are capable of exchange of energy at a simple contact but only those that store it in the form of movement such as heat, radiation, or mechanical impact. In other cases we need some contraption, machine, engine, or device to transfer energy from one system to

another, in the form of work, as, for example, from the soldiers through the ram to the gate of the castle or from the engine to the wheels trough the transmission. Living organism is the only natural invention of this kind to transform the energy of food stored in chemical bonds into work of walking, hunting, and thinking.

What follows from the tendency of all systems to equalize their energies at contact, provided they can exchange energy, is the direction of a spontaneous process, i.e., the one that is not induced from the outside. On its own, a system tends to decrease its energy by transferring it to another system with lower energy.

Note that the principle of conservation of energy alone does not forbid transformations of **B** to **A** and **A** to **A′** in Figure 25.2 if the total energy does not change. Why this does not happen had been a mystery for physics until the concept of entropy, i.e., measure of chaos, was introduced only a few years after Darwin's *On the Origin of Species* (1859) by Rudolf Clausius and Ludwig Boltzmann.

In short, the conclusion of the enriched classical thermodynamics was that in an isolated system the degree of chaos could only increase. Thermodynamics does not say, however, how soon it would happen. In order to maintain order in a dynamic system, energy in the form of work should be spent constantly. Society is a system that indefinitely postpones the fulfillment of the prophesy of classical equilibrium thermodynamics.

NOTE: Energy and entropy appear both in the so-called free energy. It is often symbolized as **G,** from the name of J.W.Gibbs who introduced it around 1870. If the temperature is constant, the change of the free energy of an isolated system is :

$$\Delta G = E - T \Delta S,$$

where **E** is what is called "internal" energy, i.e., energy in the common intuitive meaning of the world, and **T∆S** is the measure of chaotization/ordering, where **T** is temperature and **S** is entropy.

It is the free energy that always decreases when an isolated system spontaneously changes, and **G** is minimal when it reaches the state of the "non-change," the physical Nirvana of equilibrium.

From the modern point of view, the fundamental discovery of Ludwig Boltzmann was the link between energy and probability, further elaborated by Willard Gibbs and much later by Ilya Prigogine. In short, although most imaginable changes in the world were impossible as *spontaneous* processes, humans and other living beings—and nobody else—could perform improbable changes by *spending free energy*. Both biological and social evolution, therefore, are records of improbable events made possible using the energy of food (i.e., transformed energy of sunlight) and mineral fuel.

The requirement for such course of things, as we know, is the absence of equilibrium. If the regular and stable sunlight was a source of energy for the first plants, what the source of non-equilibrium could be? The changing seasons, day and night, tide, climate, winds, volcano eruptions, etc. were most probable sources that kept evolution awake, far from the mortal sleep of equilibrium. There had always been plenty of turmoil on earth even without the restless humans.

An important conclusion for a pattern historian could be that the energy of food and mineral resources could be spent by the social engine in two basic ways. One is to change its temperature in either direction, i.e. freeze the society by more regulations or heat it up by more freedom, and do it indiscriminately. Neither creates anything, however. Only work, applied selectively for designing pragmatic plans and implementing strategies, changes the social

structure either in a revolutionary way, as ideas of Jean-Jacques Rousseau, the Founding Fathers of American Revolution, and Karl Marx did, or in a gradual and systematic way as the current national policies do in various countries. The work of a politician is to form new bonds in new alliances and to break others that stand in the way.

We hope that our illustrations helped to clarify the difference between social heat and social work without making it too clear to be a target of devastating criticism. Our Lunar and Martian China and Russia alone were, probably, too much. We must say that the parallel between thermodynamics of an engine and a social system is extremely limited. If we see some similarity, a physicist would see dramatic differences. Thermodynamics study systems full of constant internal movement and capable of coming to equilibrium very quickly. Molecules of gas do not sleep, learn, and feel fear and hope. Neither they owe energy or store it. Squirrels do all that, and so do humans.
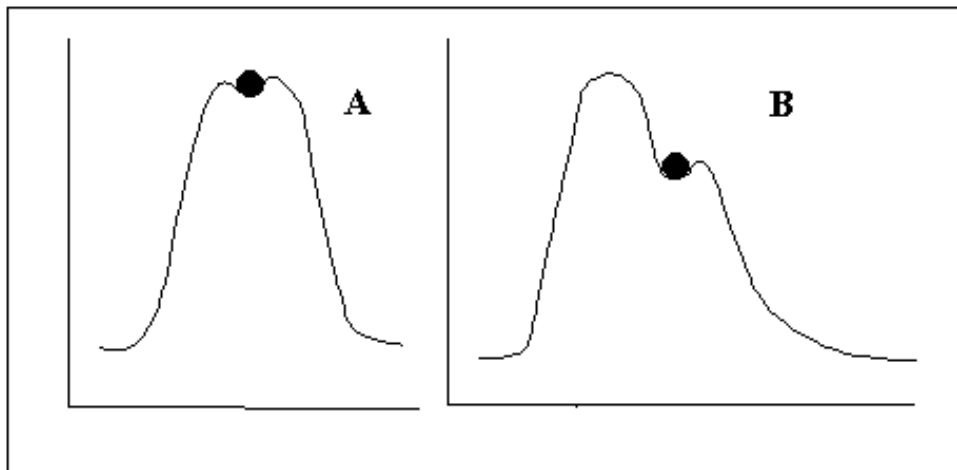

Figure 26.3. Metastable states

Living systems, from the point of view of physics, are not only far from equilibrium, but also behave as a totally different class of metastable systems, which are not necessarily dynamic. A metastable system, see Figure 26.3, may have a very high potential energy but it sits precariously in a shallow energy pit or nests on a ledge, like a resting mountain climber. A very slight jolt knocks the system off and it falls down, releasing its energy. Explosives are a good example: they are stuffed with energy and sometimes not only a detonator but a slight touch can kick them out of their sleepy hollow.

Living systems are rich with locally metastable states, especially in muscles and nerves, kept in the state of readiness and capable of firing at any moment. After discharge, they are pumped up back to the previous state by biochemical mechanisms. A living system as a whole, however, may stay metastable for a long time, as a snake waiting for prey. The same true for an individual, group, or institution in society.

Physics has no means to predict when a metastable system will release its energy because physics is outside history. History is the record of who pushed what button, when, and where.

Metastability could be illustrated by two examples, curiously, at the same geographical location. One is the San Anreas Fault, a stressed geological formation capable of releasing its energy in an earthquake. The other is the population of South Central Los Angeles in the spring of 1992 on the eve of the riots triggered by the verdict in Rodney King beating case (situation repeated in Cincinnati in 2001 for a similar reason).

Society, as any living system, is not governed by the laws of classical equilibrium thermodynamics, and not even by the non-equilibrium thermodynamics of fluid systems, because of the phenomenon of memory. Society is both fluid and solid at the same time. Moreover, its semi-solid components—culture, institutions, and records—have a complex structure which is

subject not for thermodynamics but for information theory. All we wanted was to offer some ideas how both aspects could be combined in the concept of "solid" but labile pattern subjected to uncertainty and change. While using physical terminology we always need to keep in mind the limitations of our analogies.

Answering the question of legitimacy asked in the beginning of this chapter, we would say that the world as a whole, comprising physical, biological, mental, social, and computer phenomena, probably, preserves the laws of thermodynamics as invariance under a certain transformation. It is hard to define what kind of transformation it is, but in a tentative manner, it is from one pattern system to another.

We do not need to go into further details because we neither identify social energy with physical one, nor can present any quantitative data without which there is no science. Until then, all we can do is to paint a cubist, metaphoric, and blurred study for a picture that could be completed by future enthusiasts.

We must say a few words about sociology. Its mapping on pattern theory is an enormous and exciting subject that by no means can be reviewed here. The mutual echo of Max Weber's "ideal types" and our snapshot diagrams can be heard, for example, in Chapter 19, *Testing the Ariadne's thread*, while there is a more than visual similarity between George Simmel's ideas of distance and our bell curves of transition state or the importance of triangle in his micro-sociological patters. We wish to refer the reader to *Sociological Theory* by George Ritzer (1983). It is a relatively short review that combines both conceptual and evolutionary projections of sociology with clarity and attractive organization of the material. It pays attention to concepts off mainstream and offers a rich collection of sociological building blocks. There is also record of

sociological debates whether humans really could feel, think, and plan as "molecules" of social system. The reader could find there a history of sociologists' intuitive drive toward the principles that govern society as natural system. One could see many of our pattern bones underneath the textual flesh of sociological constructs.

The question is why the borrowings from mathematics, physics, biology, and even chemistry have never produced a satisfactory and universally acceptable sociological paradigm. The answer is, probably, that theory in natural sciences is inseparable from its predictive power and experimental test.

It may take some time before sociologists with wide scope of interests realize that the only reliable prediction of natural sciences about large complex systems such as society is that the detailed prediction is largely unreliable: the systems are probabilistic. Life and evolution is always a game of chance and necessity. It is a different and yet unclear problem where the limits of predictability are.

In the next chapter we will discuss the possibility of expanding the limits.

27. History and computers

On its Web site the American Association for History and Computing (AAHC) announced its dedication "to the reasonable and productive marriage of history and computer technology." The marriage seems fruitfully consummated. There are Association for Computers in Humanities, *The Journal of the Association for History and Computing,* journals *History and Computing* and *Computers and the Humanities*. As an example, here are some titles of articles from *History and Computing*, Volume 11, 1999 :

Ken Bartley, *Classifying the Past: Discriminant Analysis and its Application to Medieval Farming Systems*

Markus Heintel, *Historical Height Samples with Shortfall: A Computational Approach*

Steve King, *Historical Demography, Life-cycle Reconstruction and Family Reconstitution: New Perspectives*

Marea del Mar, *et al, Bridging the Gap between Quantitative and Qualitative Historical Research: an application of multiple regression analysis and homogeneity analysis with alternating least squares*

The current use of computers for historical research follows their use in other areas of science: data storage and processing, calculation, simulation, and visualization. Among the suggested directions was creating virtual historical reality to familiarize the students with art and culture of the past.

Computers have already made history, figuratively speaking. Can they make it in a direct sense? In this chapter we would like to suggest some new ways to refresh the marital routine.

Historians agree that such technological inventions as stirrups, gunpowder, book printing, steam engine, telephone, contraceptives, TV, etc., changed the course of history.

Technology is a powerful, if not the most powerful, factor of modern history. Industrial revolution was, probably, the largest twist of history on a large scale, comparable with the emergence of primates in biological evolution.

To give an example on a much smaller scale, the advent of television was considered largely responsible for the victory of telegenic John Kennedy over somewhat less handsome Richard Nixon in the presidential campaign of 1960, as well as for the public opposition to the Vietnam War, the bloody images of which were brought by TV in the American living rooms. The apocalyptic TV images of September 11 had a different effect, generating a unified response at all levels.

On the bright dawn of the twentieth century, radically new technology used to create euphoria and complacency. In 1910, the telephone inspired a contemporary to write:

Some day—who knows?—there may come the poetry and grand opera of the telephone. Artists may come who will portray the marvel of the wires that quiver with electrified words, and the romance of the switchboards that tremble with the secrets of a great city.

Who could have foreseen what the telephone bells have done to ring out the old ways and to ring in the new; to ring out delay, and isolation and to ring in the efficiency and the friendliness of a truly united people? (Casson, 1910).

Not long after this amazing prophesy, Francis Poulenc in fact composed an opera basing on the drama *La Voix Humaine* (Human Voice) by Jean Cocteau. On the stage a young woman was saying the last *adieu* to her lost lover who was inaudibly cutting the remaining threads of hope over the telephone. She and the apparatus were the only visible characters of the opera, and with the sound of the replaced receiver came the final dead silence.

The treacherous combination of telephone and tape recorder brought down one American President and almost cost another President his leadership over the "truly united people." Already in the twenty-first century, the discovery and publication of the tapes of yet another American President revealed a drama of national deceit.

Computers, unlike the previous radical inventions, were ushered into the limelight with a warning from Norbert Wiener, the creator of cybernetics, who thought about a possible domination of computers over humans. His cautionary parables influenced a non-stop flood of sci-fi books and movies, and the fragments of the term he coined were used as building blocks for *cyberspace* and *cyborg*.

Computers are not the only major invention that has irreversibly changed our life. The difference is that computers do not just perform a certain ancient social function, like calculation, communication, and transportation, but stick to literally everything and penetrate every human occupation, including that of historian and writer.

With applications ranging from mailing and shopping on the Web to simulating a nuclear explosion and protein folding, the computers hooked up humans to a vast reservoir of accessible knowledge that can be extracted, processed into new one, utilized to change the world, without any loss to the reservoir. Computers are increasingly becoming an omnipresent pervasive aspect of civilization.

When we are talking about global economy, it is perceived as a fluid aggregate of a multitude of interacting business entities. Other components and functions of society, such as national government, education, religion, business, institutions, culture, are also globally multiple, fragmented, variegated, competitive, and localized. There is no single company controlling global communication, transportation, education, health, and finances. Computers, however, are forming a single uncontested global system, resurrecting, in some eyes, the totalitarian utopia on a global scale.

We euphorically expect computers to bring the entire world to our senses and fingertips. As the backside of this achievement, they established themselves as a two-ways interface and, conversely, they can bring our individual life to somebody's ill eyes and fingertips. It is a cliché to say that we are all interconnected, but the connection comes at a price: it is not direct. There is something between the connected points.

In Figure 27.1, some of four generators, **A** to **D** have direct connections, but all of them have connections mediated by a different subconfiguration with generators **E** to **I.** Metaphorically, we can call the structure in the large circle WWW or Internet. From all we have learned about catalysis and metric patterns, if some limits on total energy are imposed, which is the case in any realistic system, the changes in the affinities of **E** and **G** can change the affinities

of **A** and **B** and *vice versa*. It is simply another way to say that probabilities of some events may change the probabilities of other events or information may change behavior.

Note, however, that bonds in the outer world (real life) require "real" energy to be changed or maintained, while the electronic bonds between the generators of the inner circle are all close to neutral and need a merely symbolic quantity of energy to change. This gives an unprecedented social power to the mediator as collector, processor, and distributor of information. Even the human brain does not have this kind of power over the body because with all its

Figure 27.1. Possible configuration with a mediator (large circle)

biochemical efficiency it requires a lot of energy and time to select a task, acquire information, develop strategy, follow its execution, and discard the outdated knowledge.

This could be, in short, the pattern reason for what many people intuitively feel as the great evolutionary novelty of the Internet: it creates the prerequisites of global brain even without material centralization of its functions at one place.

At this point we cannot say that the brain has opened its loft to consciousness, but the subconscious basement is up for rent.

In a sense, computers have increased the distance between us and the real life, making more room for a shadowy world where abstraction, fantasies, and facts could be difficult to discern. Throughout this book we emphasized the Spinozean distinction between things and thoughts, sign and meaning, images and configurations, but the computers are not the best tools

to keep them apart. The acceptance of what is seen on the surface, the sign, as the only reality is typical for the postmodern culture.

It is commonly believed that computers assist our logical thinking, but, as it turns out, their combinatorial potential is equally great in creating monsters and chimeras. The computer anthropologist Sherry Turkle in her *Life on the Screen* (Turkle, 1995) describes the imaginary world of collective computer games over the Internet where a young person can develop a virtual personality different from his or her own and live in a surrogate of real life. It has been known since long that when the sleep of reason produces monsters, as Francisco Goya entitled

Figure 27.2. The Sleep of Reason Produces Monsters (along Goya)

one of his *Caprichos* etchings, see our variation on his theme, Figure 27.2, but whether the virtual monsters can put the reason to sleep remains to be seen.

There is a certain parallel between the new, still off-mainstream, cyber-culture and the postmodern trend of smearing the razor-sharp dichotomy between true and false, fact and fantasy. Virtual reality is a blend of both.

Our task in this chapter is not speculation on the future of humankind, however, but some insight on a specific role that computers may play in pattern history.

When we start fantasizing about the future, any scenario is possible. A sudden wealth can fall from the skies and a nuclear accident can devastate a large area. The probability of some events is very low while others seem imminent. A war with the participation of Switzerland or Sweden is improbable, while violence between different ethnic and religious conclaves in close contact is on the cards. Yet the improbable events are major turning points of history.

History is what should not have happened. *Post factum*, historians would find dozens of reasons for what had happened indeed.

The collapse of the Soviet Empire is one example. On the one hand, the very act of a collapse of an empire is a typical act of history which has been repeated throughout millennia. It is as typical as the formation of an empire, and we can say about any political and industrial empire that it will end badly. On the other hand, the question of time and place is crucial. It is not the pattern but time and place where predictions fail.

The dubious property of computers to create virtual reality may come very handy for pattern history where we need to compare arrays of final states and transition pathways to them. In particular, computers can help overcome the major simplification that we have imposed on this book: the non-numerical approach.

Since ancient times people believed it possible to know their future. If the world is driven by divine will, it is only natural to look for some signs of it, like we read the mood by facial expression. Oracle, diviner, augur, clairvoyant, astrologer, reader of tealeaves and bird entrails, and their modern counterparts have been performing a certain social function up to present. Today the guild embraces also political commentators. "What do you think is going to happen...?" is the first question addressed to a political analyst on a current or future media event.

In Chapter 4, *Alternatives and altercations*, we mentioned the famous oracle of Delphi. Ambiguous and enigmatic, it did very well because of the incompleteness of its predictions. Cassandra, the Troyan princess who rejected the overtures of Apollo, was punished by the god in a very cultivated way: she was given the gift of prophecy but nobody believed her when she had warned about the Trojan Horse.

Among modern prophets we would like to mention two. The American historian Crane Brinton right after WW2 predicted the unification of Europe basing not on any pragmatic considerations or wishful thinking but on the long-term European pattern of unification that could be traced through its history.

> About 1100 A.D., for instance, it was sweet and fitting for a man from Normandy to die and kill for his duke, and for a man from Paris to die and kill for his king. Subinfeudation may have confused many good men in this matter of ultimate loyalties, but they all thought the ultimate loyalty could somehow be found on earth. Within a few centuries, Normandy became, as we say coldly in the textbooks, a part of France; Normans became Frenchmen, and no longer legally killed Frenchmen. What is true of Normandy eventually became true of Brittany, Flanders, Languedoc, Dauphiné, and all the rest of what now seems to some of us *la France eternelle.*(Brinton, 1971).

The recent events in former Yugoslavia fit the same pattern: European nations were reminded that they belonged to a larger entity and were not allowed to kill each other.

The other prophet was Andrey Amalrik, a Russian dissident who, in 1969, when the Soviet power was at its peak, predicted the dissolution of the Soviet Empire along the ethnic cracks. He chose the year of 1984 under the spell of George Orwell.

The fact that Crane Brinton in the 1940-60's was as prophetic regarding the unification of Europe as Andrey Amalrik was in 1969 about the split of the Soviet Union, offers some grounds

for optimism about the possibility to interpolate history and flip the flashlight 180 degrees into the future. It is always risky, however, to specify time and place. It is more natural for a sociologist: general sociology is history minus time and place.

The time of evolution, as Ilya Prigogine argues, has nothing to do with the clock and calendar, yet this is exactly what we want the oracle to tell us.

We associate science with a set of established principles that can be tested experimentally or by observation of predicted phenomena. We can successfully formulate the laws of history as a sequence of banalities, like *any empire is doomed*, or *any political leader is a liar, or Eastern ways are different from Western ones*, or *a mass discontent ends up in a revolt*. If we want to go beyond the all-I-need-to-know-I-learned-in-the-kindergarten type statements, we need to specify time and place. We need to formulate such universal principles that could be tested. By definition, however, universal principles have little to do with the need of the moment and the immediate future because they are too general.

We tend to think condescendingly about our ancestors thousands of years ago, afraid of the world with its frightening gods, and trying to solicit their benevolence with sacrifices.

Not long ago educated people of Europe and America used to call the tribes without metal tools, agriculture, and literacy savages. Yet we, civilized people, can easily experience the primitive perception of the chaotic and hostile world when we think about social history: the major catastrophes of this century came as unexpected as a tornado.

As and example of an apparently wrong prediction, not long before the WWI, in 1910, a book was published—*The Great Illusion* by Norman Angell—in which the author argued against the possibility of a prolonged and destructive war because it would have no winner.

In pattern terms, we could interpret the thesis of the book as the assertion that the final post-war state would have such a high level of frustration that it would not be possible to achieve it through desires of reasonable people. It was achieved, however, and in fact, it was so high that Europe easily slid into the next war.

The prediction was wrong concerning WWI, but it was prophetic regarding the world after WW2, when the nuclear weapon, as many believe, started playing a deterring role. We do not have a proof and the situation may quickly change if the weapon proliferates among relatively small states under dictatorial rule, but the prophet was right, as far as reasonable people were concerned.

Niall Ferguson starts his *The Pity of War* with the analysis of pre-WW1 prophetic literature. He discovered an amazingly correct prediction about the character of the possible war written by one Ivan S. Bloch, a financier from Warsaw (Ferguson, 1999, p. 9).

It seems that all the prophets face the neo-Cassandra dilemma: they have a point, but nobody can locate the point either in space or in time.

Right before the French Revolution one Danton changed his name to d'Anton, and one Derobespierre turned into De Robespierre. This anecdotal fact was of no historical significance. For the two men, however, it was a crucial circumstance: by presenting themselves as aristocracy they automatically inflicted future persecution by the Revolution.

When Hitler came to power, predictions split. The pessimists left Germany and saved their lives. The optimists and coin flippers perished by millions.

A less trivial example is quoted by Leon Festinger in his book on cognitive dissonance.

During World War II, some Japanese in the United States, when given the opportunity, requested that they be repatriated to Japan at the end of the war. Those who were citizens of the United

States and requested repatriation thereby renounced their citizenship. For all of them, citizen or not, the request for repatriation was an irrevocable act. At the end of the war they were to be returned to Japan. Apparently one major difference between the many who did not request repatriation and the few who did was the belief they held concerning the outcome of the war. While the majority of Japanese in the relocation centers believed and hoped that the war would end in a negotiated peace, most of those who requested repatriation firmly believed that Japan would win the war (Festinger, 1962, page 244).

Is a customized forecast of the future—other than palm reading—possible? If it were, the two Frenchmen could just look at the gauge and see that the time was not right for snobbery.

The picture of tomorrow immediately influences our decisions to accept or to avoid it. Can it be done not only by visionaries but on everyday basis, with computers on hands?

While history runs its course, there is always something else running a parallel track: the weather. There is at least one area of natural sciences that specializes in predictions: the Earth sciences such as meteorology, global ecology, and seismology.

Barometer was invented in Italy 1643 by Evangelista Torricelli, Galileo's secretary and successor in the Florentine Academy. His invention is still used for telling the coming weather. Aided by new technology and computers, the art of predicting a catastrophe such as hurricane or earthquake has been slowly developing, and we may wonder whether the social prognosis could follow meteorology. With hindsight we understand that the escalation of Islamic terrorism was heading to its catastrophic culmination in Manhattan. Could we foresee it as clear as the coming storm? Some people did.

With so many social functions performed electronically, someday we may be able to click on the Internet button of the world social weather. We certainly do it today by accessing the news button, watching TV, or reading the newspaper. For the entire twentieth century, the gauge to measure the tension in the air has been the font size of front page headlines.

Today we have several organizations working as a barometer of the world weather, and they are present on the Web, too.

One of them, the Worldwatch Institute, publishes periodical data about the vital signs of the earth. We learn from them that the production of automobiles, bicycles, spending on advertisement, use of wind power and solar cells, life expectancy, and number of wars are growing, while the production of automobiles, sperm count, grain harvest, and nuclear arsenals are on decline.

The statistical data indicate the parameters of a quasi-equilibrium dynamic system with large number of interacting entities, as if it were a fluid. We cannot conclude from them what is going to happen next year in Yugoslavia or Namibia. The climate is global, but the weather is local.

Stratfor is a private global intelligence company that issues political forecasts.

Here is the forecast from December 24, 1994:

The decade ending 2005 will be marked by two contradictory trends. On one hand it will be a period of unprecedented global economic prosperity and growth. On the other hand, it will become a period of increasing fragmentation and tension in the international system. As in the period prior to World War I, prosperity and instability will go hand in hand.

There is also the yearly forecast from January 4, 1999:

Russia will begin the process of recreating old Soviet empire in 1999. The most important question of 1999: will Ukraine follow Belarus into federation with Russia?

Russia and China will be moving into a closer, primarily anti-American alliance in 1999. Asian economies will not recover in 1999. Japan will see further deterioration. So will China. Singapore and South Korea will show the strongest tendency toward recovery.

China will try to contain discontent over economic policies by increasing repression not only on dissidents, but the urban unemployed and unhappy small business people. Tensions will rise.

Asia will attempt to protect itself from U.S. economic and political pressures. Asian economic institutions, like an Asian Monetary Fund, will emerge in 1999.

The Serbs, supported by the Russians, will test the United States in Kosovo. There is increasing danger of a simultaneous challenge from Serbia and Iraq, straining U.S. military capabilities dramatically.

The predictions about Kosovo and economy of Japan came true, but the decisive way NATO responded to Kosovo was not foreseen. The Chinese government in fact responded with repressions to Falun Gong movement. The economics of Japan is still shaky. Russia is preoccupied with her own problems and is not interested in China. The turn of events after September 11 changed the overall picture dramatically.

Like the atmospheric conditions are driven by the inequality in distribution of land, water, mountains, plains, and solar radiation over the surface of the world, the social, cultural, and economic non-uniformity of the world generates the historical climate and weather. The general trend of the twentieth century has been toward narrowing the gap between the tribes of Amazon and residents of Paris, but the difference remains enormous even among the latter.

What we can imagine is applied history which could, with some degree of accuracy, like meteorology, tell us what is going to happen within a particular time and space.

While the yesterday's news are synonymous with irrelevancy, the pattern survives in the information dust not in the sense that the same pattern will be repeated again—some will be and some will be not—but in the sense that the change and evolution of all patterns can be described in the same terms. In other words, we are pointing not to particular patterns of history but the pattern paradigm as a possible platform for the applied study of complex evolving systems. The paradox in our attitude toward history is that what is predictable is either of no importance or within our power to prepare to it and either welcome or to prevent the change. Does it make

sense to study history in search of omens for something that has never happened before? It certainly does make sense to search for patterns.

We can draw a parallel with biology here. Since Aristotle, biology was a descriptive and empirical science. It experimentation with nature was limited to selection and breeding. After Charles Darwin and Gregor Mendel it became an explanatory science based on powerful hypotheses without the exact knowledge of the mechanisms of evolution and heredity.

The long gone ammonites, dinosaurs, and Neanderthals are history in the same sense as the Roman, Austro-Hungarian, and Soviet empires, but for a paleontologist and evolutionary biologist they all fit the same evolutionary paradigm, whether we know which species originated from which or not.

In the second half of the twentieth century, biology is a truly experimental science intervening in the genetic code and creating new organisms. This became possible due to instrumentation and measurements. Gregor Mendel was measuring the numbers of pea flowers of different colors and Antoine Lavoisier weighed the candle before and after burning it in a closed vessel. Scientific meteorology started with measuring temperature, atmospheric pressure, and wind velocity.

For us the weather forecast "70% chance of rain tomorrow," is an understandable expression but a mathematician could be uncomfortable with this statement. If we had 1000 tomorrows, then we would expect about 700 of them to be rainy, but we have only one tomorrow. The meteorological forecast is, actually, nothing but a historical record: from many measurable observations and based on them calculations, the conditions like the present were followed by rain in 70% of cases.

In social evolution there is no statistical ensemble. The past and the future are unique. What predicting power can any theory of history have?

History is like a chemical reaction with a single molecule. If we had a thousand planets like Earth, with a thousand of identical situations, then probably on one of them the same inefficient government would manage the appropriate reforms due to some accidental set of circumstances. But we never have any statistical ensemble of social transformations from the same starting conditions. It may seem that Pitirim Sorokin's tables of wars and calamities offer such statistics, but they comprise different conditions, times, and places. They should have been compounded over the Star Trek civilizations.

The media present locally a daily list of events and current forecasts. The problem with the media is that what is not in the news does not exist for the reader or TV-watcher.

Starting from the twentieth century, the previously voiceless masses have been heard through the opinion polls. Their most intimate desires can be registered in consumption statistics, not to mention fear, hope, and stock market indices. They pull the levers of the society by voting or non-voting, not always with anticipated results.

In the twenty-first century, whether the masses want it or not, their behavior, urges, impulses, hopes, and fears will be most probably pooled in the ocean of global information. The electronic network of connections, from telephone to the Internet, for the first time in history makes the dream of all dictators real: to have an objective and accurate picture of the behavior of an individual. The simple fact that the modern telephone system automatically records the date, time, and connection between two numbers plays an increasing role in criminal and political investigations. Nobody, not even the US President, is free from this Orwellian watch, which would be impossible without computers.

The new factor is that the exchange of information can now be measured and monitored both globally and locally. Web filters can be used for both discarding the undesirable information and fishing out the desirable one.

Historians seem to have abandoned search for the timeless laws of history and global regularities as eternal and powerful as the laws of physics. Such laws are of little practical use exactly because they are timeless. Instead, there is a possibility that the flow of events can be monitored and prognosticated on a constantly updated basis as we do it with the weather. Social, economical, and political factors can be compared with the outline of continents, only the former change constantly and discontinuously. With all the differences between fluid weather and structured history, a computerized global model is needed for both.

In the developing World Wide Web we have an emerging computer model of the world without even having asked for it. The Web is usually regarded as a new convenience, providing information and assisting trade. We pay for the information on the Web, however, not only with money, quite modest at present, but also with our identity, address, telephone, social security and credit card numbers which are part of our unique individuality. For the first time ever this model has a potential for representing both thoughts and actions of people in a quantifiable way, locally and globally.

What the computers bring to history and sociology can be compared with the microscope in biology, balance in chemistry, thermometer in physics. Unlike the current use of computers in history for data processing, computers can accumulate quantitative historical data without the participation of the sociologist or historian.

The instrumentation turns observations and descriptions into science. More important, computers potentially bring to history what they have brought to physics and other natural

sciences: the power of simulation of large ensembles, the "gigabyte technology," the head-on, super-power, scorched-earth approach to solving complex problems by creating a simulacrum of the object.

Note that non-numerical evaluations are built into the common historical narrative.

With striking awkwardness, the government offered with one hand what it withdrew with the other (Brinton, 1966, 34).

This phrase tells us about a hidden reference to a certain scale on which to evaluate the work of the government: some governments are efficient and consistent while others are awkward and self-contradicting. This is not what is called a historical happening, but rather a semi-quantitative measurement which allows for building a scale of efficiency similar to the Sorokin's register of calamities. In other words, it tells us something about the generalized energy of historical configurations.

Simply speaking, the above Brinton's statement attributes a high tension to the pattern of French government on the eve of certain events, which could only mean a high probability that the government would not survive.

This quasi-numerical scale has been widely used in social psychology and sociological polling. For example, the answer to the question "How attractive is this playmate?" can be marked on a linear scale from 0 to 100 with some guidelines (Higgins, 1996, Vol. 2, p. 535):

0	20	40	60	80	100
Not at all	Slightly	Moderately	Very	Extremely	
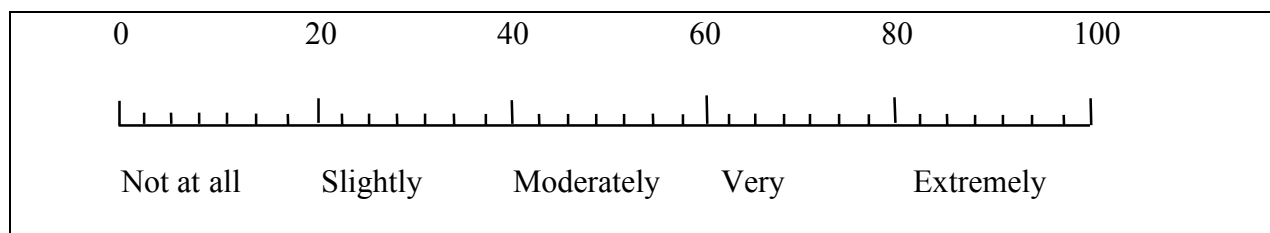
Yet numbers are an essential element of the apparatus of pattern theory. We calculate in order to see what cannot be seen with the naked eye. Without quantification, our insight will be reduced to banalities.

It is the bond relation that asks for quantification in the first place.

To remind, regularity R is:

$$R = <G, \rho, \Sigma, S>,$$

where :

G is generator space,

ρ bond relation,

Σ connector, and

S similarity transformation.

It is relatively simple to keep record of generators: institutions, personalities, and groups that come and go. We can also observe the dissolution of bond couples and the development of new social affinities and idiosyncrasies. It requires some level of creativity to specify the similarity transformation that links the old and new structures, although the problem here is not that much a lack of imagination as its possible hypertrophy.

The major difficulty, as we see it, is the bond relation expressed statistically.

With the development of WWW not only the links between various social generators are becoming visible, as in the hypertext, but their strength can be quantified in terms of the frequency of hits (positive affinity), budgetary expenses for maintaining social order (cooling the chaos), or spending for weapons and family counseling (maintaining negative bonds). With the

help of this apparatus we can watch the transformation of the pattern in real time, evaluating the strength of such bonds as parents-children, husband-wife, elected official-electorate, etc.

For example, U.S. Bureau of the Census (www.census.gov) reports the following eloquent data about the percentage of never married people in US in 1970 and 1998:

Age	1970	1998
Never married male:		
20 to 24 years	35.8%	83.4%
25 to 29 years	10.5	51.0
30 to 34 years	6.2	29.2
35 to 39 years	5.4	21.6
40 to 44 years	4.9	15.6
Never married female:		
20 to 24 years	54.7%	70.3%
25 to 29 years	19.1	38.6
30 to 34 years	9.4	21.6
35 to 39 years	7.2	14.3
40 to 44 years	6.3	9.9

The natural conclusion of a pattern historian or sociologist, as well as a person from the street, could be that the bond of marital attraction between sexes is getting *weaker*. Remarkably, the percentage of divorces in the population remains the same: 3.5% in 1970 and 1998, although the percentage of marriages, naturally, relates as 10.6 in 1970 and 8.4 in 1998.

The question is how to explain that. One explanation of this weakening of the marital bond could be attributed to the rising social temperature due to uncertainty, changing condition, higher mobility, catalytic influence of the hedonistic culture glorifying the ephemeral at the expense of the permanent, and general chaos of life leading to nervous breakdown, not to say marital catastrophe.

Another possible explanation is that the other types of bonds that people form are getting stronger, so that the total energy of the configuration remains nearly unchanged. We do not need to look far in search for the object competing with humans for human attention. It is all the

money can buy in the Epicurean mall: cars, computers, career, gadgets, comfort, sports, travel, homes, virtual reality, alcohol, drugs, etc.

We do not know the answer, which is up to professional sociologists, but we would recommend a statistical monitor that makes distinction between temperature and work. For example, if we find that the average time of owning a certain thing goes down (and it looks as it does), the reason is the rising social temperature. If the general number of things in possession goes up (and it looks as it does), it means that they are winning the competition with family and friends. If the temperature goes up, sooner or later, it will manifest in outbreaks of violence (and it looks as it does: note guns in schools and offices, LA and Cincinnati riots, Seattle demonstrations, and environmental crime). By no means want we to pretend that we know what is going on: we only demonstrate the mode of reasoning.

This world wakes up to numbers. Economical indicators trigger the powerful Federal Reserve action. We are flooded with statistic in the form of Nielsen report, electoral and exit polls, crime and roadway statistics, Internet polls and countless others. We can argue about their reliability and accuracy, but it can be improved and standardized.

The following are some polls from ABC news site, June, 1999:

1. Do you have a good relationship with your father?

Yes 61.4%. No 17.5%. Total votes 7,778.

2. Gambling is:

Bad for society 48.5% . Good for the economy 14.9%. Both 48.5%.
Total votes 24,610

3. If I had to pick the president, I'd vote for

George W. Bush 67.6%. Al Gore 32.3%. Total votes 43,884.

4. Slobodan Milosevic is:

Going to be as hard to get rid of as Saddam Hussein 89.3%. On his way out and soon 10.6% .
Total votes 27, 167

The polls, as ABC warns ("Remember, these are not scientific samplings. But they are an excellent way to share your views on the issues of the day."), are not statistically valid. Nevertheless, they contain some information about the father-child bond among not too busy Internet users on a day in mid-June 1999, to a possible envy of Sigmund Freud and James Joyce.

Internet, therefore, appears as a potential model of the world, possibly, distorted, but with a chance to account for the distortion. Unlike previous statistics, it is almost instantaneous.

The emphatic intensity of the language in quotations from leaders and rank and files can also be measured and used as indication of the temperature.

The prophesy of the poll about Bush and Gore, which was mostly intuitive, seems less remarkable than the subsequent shift of the balance to a draw by the heavy propaganda dumbbells put on the balance of the campaign.

The prediction like the following, for example, can be made quantitative by monitoring the level of discontent, repression, unemployment, and general unhappiness.

> China will try to contain discontent over economic policies by increasing repression not only on dissidents, but the urban unemployed and unhappy small business people. Tensions will rise (Source: Stratfor).

Whether the tensions in fact rise or not, comes always, like the chances of rain, with a random component. And yet if there is any identified contribution to the rise of temperature, the chances are good that the tension will rise. In pattern terms, such factors can be expressed in the

rising number of negative bond couples in the social structure or the decreasing supply of energy necessary to keep the negative bonds locked.

Stratfor, the company offering the above prediction, generates its forecasts by, among other sources, analyzing email and Internet information.

This is where we see the decisive role of computers in "making history."

The major idea that we want to express here is that instead of probabilities and philosophical difficulties connected with the definition of probability, as well as the need of a large number of samples and the principal impossibility of applying probability to unique events or small groups, the statistical data, however limited, can be interpreted in terms of affinity or strength of a bond couple. What a historian can extract with the help of computers, which are doing their job anyway, is the visualization of a changing social pattern as points and lines subjected to operations ADD, REMOVE, BREAK, CLOSE, and MODIFY.

We are far from thinking that such industry of a somewhat Banthamian-Orwellian brand would be good for anybody. History, however, never asks humans for any consent or approval. It simply happens, and next day the historians have to rewrite their books. As we believe, knowledge offers us an advantage in standing against any dictate, even that of history itself.

After so many gone empires revisited in this book, we are tempted to paraphrase Andrey Amalrik's question: Will the USA exist until 2084? It seems like a long shot, but the Y2K problem came sooner than everybody expected. The children who are born today will live in those faraway days.

Theoretically, USA, where the mutual obligations of government and population are secured not by mentality but by law, is not immune to separatism. In practice, none of the states has resources comparable with the rest of them. The Civil War was possible because the states

split into comparable warring coalitions and a new imbalance of any kind may create a similar situation. Modern USA seems to feel an increasing stress between the pattern of equality that presumes distinctive components and the pattern of the melting pot that is supposed to blend the separate components. There are always at least two ways to compensate for cognitive dissonance.

As Heinrich Heine once said, everybody can be virtuous alone, but for the vice you need two. The immiscible components with high melting points are, probably, the best candidates for the generators of future conflicts. Thus, any bilingual or multilingual tendency raises the melting point of the components. Whether the melting pot can liquefy even the pattern heritage of those Anglo-Americans who designed this unprecedented social configuration, is a politically charged question and we better stop here.

Today we think about a historian as somebody researching the past, often very distant, at best through field work, but not on the battlefield. In the very beginning of history as art and science, Thucydides and Flavius Josephus chronicled *contemporary* events they witnessed and took active part in. Who knows, maybe history, armed with computers, will make a full circle.

It is not accidentally that nowhere in this book we gave a definition of what we understand by history. The concept of history, as both events and their description, past and present, and present and future, evolves and changes. History is kneaded and baked every day, like bread, and it comes in a wide variety of shapes.

28. A sunny day in September

The terrorist attack on America on September 11, 2001 made the portentous words *history* and *historical* sound commonplace. History became a way of life—something that happens only a few times in a century, and the century was not even one year old.

In November, 2001, while this line is being written, even the human dimensions of the attack are not fully estimated and most of the thousands of the dead are not buried yet. It is a good time to use lofty words but not a good one for a cool-headed historical account. Anything that is written bears a time stamp.

No one can predict the economic dimensions of the war. The counterattack against terrorism is in progress and nobody knows how long it will last. The enemy is invisible. The source of anthrax is unknown. Some allies are shaky. The innocent far away are hit with one hand and fed with the other hand of the same uniformed body. This confusion is exactly the

reason why we believe that we are witnessing a birth of a historically new pattern of a conflict: we do not recognize a familiar one.

We can see how understanding is slowly crystallizing from chaos but it cannot be completed until everything is over. Even if it is over, it will be revised and reinterpreted, both factually and counterfactually, as we saw on the example of WW1.

Counterfactually, we already can see how easily the disaster could have been prevented or how it could be much worse. The transition barrier on the fatal day was very low and the array of final states very wide.

In the Prologue we promised to demonstrate an apparatus for looking inside history. If we simply placed the events of September 11, 2001 on the examination table just a couple months later, we would not see any skeleton: the information could not have ossified yet.

What we can do is to search for the patterns of the past that **seem to be recognizable** in the fragmentary picture. This is what we see, but somebody may see something else.

Here is an open-ended record of our observations by November, 2001.

1. Initial state. September 11, 2001 was preceded by a decade of economic growth, uncontested superiority, and untested complacency. On a smaller scale, with higher resolution, we can see the end of industrial growth, collapse of the "irrational exuberance" of the stock market, and an apparent turn of economic tide. None of that would be considered as historically new, however. There were no signs of any national crisis. The American society was (and remains) incredibly open and unrestricted as compared with most of the world.

Thermodynamically, any sharp local difference in parameters means that a dynamic system is even farther from equilibrium than in the absence of the contrast. New local gradients create forces and flows that tend to restore the previous state of the system.

Thus, as a curious example of the generality of abstract thermodynamics, the flows of money and alcohol in opposite directions across the New Hampshire-Massachusetts border tend to minimize the local gradient created by the absence of sales tax in one of the neighboring states. Similar flows of labor and money meet across the US-Mexico border. As result of the flows of refugees to Western Europe, the tensions decrease in the source countries but somewhat increase in the recipient countries.

The sharp contrast between the openness of the US society and the tightly built restrictive societies creates a similar gradient across the permeable US borders. The conflict in another part of the world can be easily transferred on the US soil. In response, it can be transferred in the opposite direction, as it happened many times, at a high economic and social cost of a military conflict.

In spite of all the political diversity, various internal conflicts, local tensions, and the existence of two mutually unfriendly political parties of approximately equal weight, American society has been successfully maintaining a very low level of social anxiety. The change of the internal structure of American society toward a more restrictive one would face a very high transition barrier because of the general satisfaction of the society with the current way of life known simply as freedom. It was economical and political freedom that made America a deep attractor on the landscape of the troubled world.

On the contrary, the world of Islam, also heterogeneous, seems to be in an internal conflict between the radical interpretation of Islam and the liberal one, with Saudi Arabia and

Taliban at one and Turkey and Malaysia at the other end of the spectrum. The Islamic world is in a stressed position, closer to the transition barrier. It may be a far-fetched comparison, but the Western ideas start playing a role similar to that of the French *philosophes* in France of the eighteenth century. The voices of the Islamic clerics, however, have been much louder, better amplified, fortified with oil money, and the message much simpler.

In search for familiar patterns on a smaller scale, we may note similarity between radical Marxism and radical Islam. Looking for a supporting view, we would refer to an uncommon pattern historian V. S. Naipaul, the recent Nobel Laureate in literature. In *Among Believers*, (Naipaul, 1981) he sees the same pattern of the dogmatic search for justice in both Marxist and Islamic revolutions. One of the concluding chapters in his book is entitled *The Interchangeable Revolutions* (i.e., Marxist and Islamic), which is exactly the point of our Chapter 13: *Two Velvet Revolutions.*

2. The pattern of ritualistic control. Contrary to popular opinion and as one of the authors can testify, a totalitarian state in a period of stability is not necessarily a gloom world of mass suffering. It may look bleak for a visitor from the free world, but its inhabitants can laugh, sing, create, and feel happy as much as people in the free world. The American writer William Saroyan once noted that the loudest laugh can be heard in prison.

The secret of well-being in a totalitarian state is the code of behavior. The Russian Communism, for example, was neither science, nor philosophy, nor politics: it was a way of life. It allowed a significant degree of personal freedom, encouraged personal achievements, equality (with a few exceptions), and did not intrude into personal matters. All it required was to perform certain rituals: vote for a single candidate without an opponent, attend political meetings,

applaud when expected, pretend studying Marxism, and never express in public a certain array of explicitly denounced views. It was, probably, a much more liberal atmosphere than in the Massachusetts Bay Colony.

The pattern common for both was the ritualistic control: the rules of behavior should be followed, including appearance. Nobody can control what people think and what they say to each other in private. What they say in a narrow public circle can be controlled by informers. The code of behavior enforces the unity of the society as much as military uniform strengthens the unity of army.

Any fundamentalist ideology, whether religious or secular, creates a close quasi-military cohesion between followers by controlling selected aspects of behavior, from appearance to rituals to obedience. It does not necessarily mean that the cohesion will be abused and aggressively misdirected by the leaders. It only means that people are expected to follow the leader or leadership by their uniform and enthusiastic behavior.

It seems that the radical and violent interpretation of Islam follows the same pattern.

We attempt to present the pattern graphically in Figure 28.1, remotely similar to Figure 25.1.

The pattern of the Communist control would substitute "self-sacrificial" for "suicidal." The need for self-sacrifice was justified by the good of the future generations.

If so, the same forces that over centuries guided and pushed the Puritan Yankees toward modern American way of life will work on fundamentalism around the world. Until the forces last.
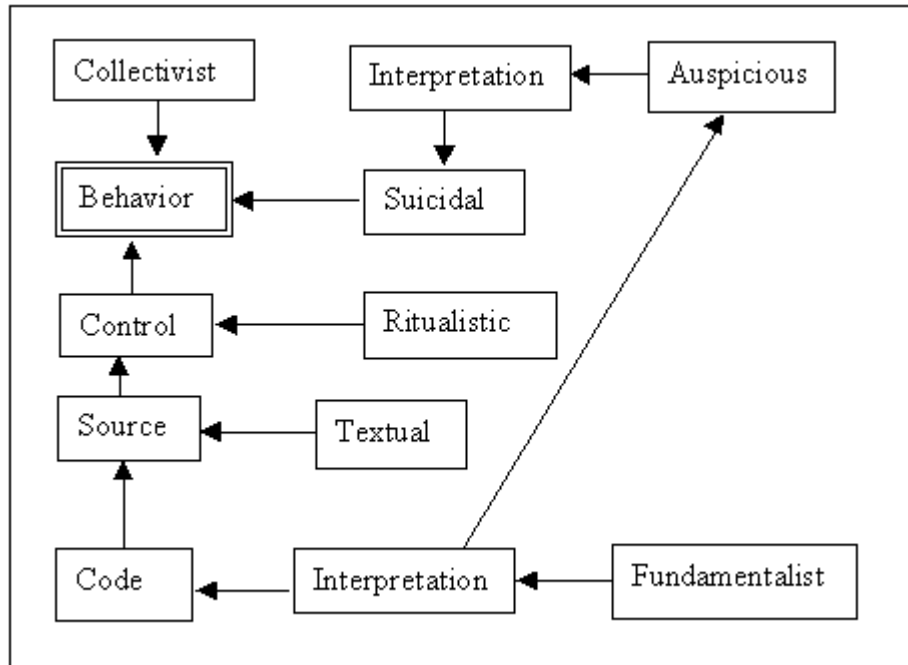
Figure 28.1. Pattern of ritualistic control of behavior

The Soviet ideology right after the revolution was extremely militant. Its final goal was destruction of world capitalism. A popular Russian revolutionary song had even a suicidal note: "We shall go bravely into the battle for the power of the Soviets and we shall all to the last man die in this fight." Subsequently, the ideology was drastically relaxed.

We remember that militant radicals inside the Soviet leadership were contained for a long time after the experiment with Cuba. They won on the question of Afghanistan invasion, only to be completely ousted from power later.

We are interested, however, in ideology more than in politics.

The monolith Marxism that set the goal of violent destruction of capitalism split immediately after Marx's death. It generated the whole gamut of shades from liberal revisionism to militant Communism. Historically, the radicals lost while the revisionists gained.

This fragmentation of a doctrine is a pattern in itself and there is no better illustration than the Protestant movement and fragmentation of the original Christianity into innumerable coexisting branches. There are well known ancient divisions even inside Islam. The relaxation of the militant and xenophobic drive may be the most probable future for Islam as well.

The great paradox of fierce and entrenched conflicts turning life into a permanent transition state and taking all normalcy away from life, as in the Middle East, is that each side expects the enemy to be smarter, learn faster than itself, and ask for peace as result.

3. Transition state. By definition, transition state is fluid and changing right before the eyes of the observers. Let us take a look at it on a specific day, say, November 13, 2001.

Part of the transition state is already in the past. It started as an external shock that sent the national adrenalin sky high within a few hours. The fact that the attack did not quite fit the known pattern of Pearl Harbor could only add to the anxiety. The initial stress gradually subsided, however, from apocalyptic to pragmatic level, and the national leadership clearly played important role in this process.

It is possible that in ten years history will have a much downsized perspective of the current conflict.

We can see how the initial high pattern temperature is subsiding: the media return from a complete domination by the attack to entertainment and from guess and rumor to critical analysis, the Congress shows signs of partisanship after the short period of overall unity. The next "bad news" (the crash of Flight 587) does not hike the temperature to the previous highest level, while the next "good news" (liberation of Kabul from the Taliban) brings a mixture of some concern with much enthusiasm.
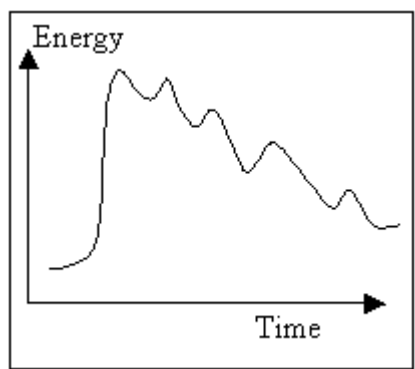
Figure 28.2. Relaxation of transition state

The initial transition state relaxes trough a series of steps, Figure 28.2.

The high energy of the transition state comes not only from its high temperature and ensuing chaos, but also from its configuration.

The new alliance is formed from inherently incompatible components. It has the typical "unnaturalness" of the transition state. Many of its Eastern participants—Pakistan, Iran, Indonesia, and Saudi Arabia—are itself highly stressed by internal and international conflicts. Japan and Germany are constrained by their historical memory, while Britain is encouraged by her own. The ties with Russia and former southern Soviet republics are strengthening right before our eyes. The ties with Saudi Arabia are under severe criticism.

The ongoing transformation of the configuration, strikingly similar to a mechanism of a chemical reaction, is what we have seen in the French Revolution, WW1, and the collapse of Communism.

Looking through the tiny peephole of the media, which is all most of us can do, we may not see the complete picture. The President, apparently, gets the best view of the transition state while it twists, stretches, and quivers, as desert mirage, but not the whole truth either because there is no such thing as "truth, the whole truth, and nothing but truth" in the transition state of a complex system. It is probability, probability, and probability.

The perspective may be very different, of course, depending on what country shoots and edits the documentary of the events and how much fiction it adds to the final film.

We would like to emphasize here an important aspect of our approach. The points and lines of the title of this book do not mean that every statesman, analyst, or historian has to draw diagrams made of circles and fancy lines to justify his or her salary and confirm prestige.

Historical narrative, fiction, nonfiction, textbook, memoir, movie, diagram, animation, semantic network, production grammar, pattern dynamics, presidential library, tape recording, secret files—all those forms are representations of knowledge, best suitable for different particular purposes. What we are saying is that behind each such representation we find a set of generators, rules of regularity, configurations, and behind some sets of configurations we find patterns.

Generator, configuration, and pattern are mathematical abstractions. They permit us to study all of them in the same language under the all-encompassing aegis of however incomplete thermodynamics of non-equilibrium systems. They can be visualized, if needed, by points and lines, but the mathematical abstraction itself is not its visualization.

Back to the transition state. We can see in it the curious property of the pattern of conflict, inherited from the initial state: the sides of the conflict are drawn to each other. On the one hand, the flow of dollars for the Saudi oil, Egyptian position in the Middle East conflict, and Israeli defense created a high concentration of energy in the area and permanent high temperature. Terrorism flourished in this thermostat like anthrax in a petri dish. On the other hand, the most ambitious terrorists seem to be in unrequited love with the Great Satan. They are locked up in a deadly embrace with the West who makes it easy for them to increase their personal influence and send tremors all over the world.

It is, curiously, the same "fatal attraction" that we witnessed between Capitalism and Communism in the Cold War: Communism desperately needed a powerful enemy to justify the

poverty and anti-democratic regime in the USSR, while the US military-industrial complex might have had its own Freudian urges.

It is the ancient pattern of the quest for world domination that drives large scale conflicts, and we may wait some time before the true intentions of the sides become clear from historical studies.

Finally, we want to refer the reader to Chapter 21, *Ideas and actions* and the role of ideas in history. In the exchange of goods and ideas, the flow of soft drinks from West to East vastly exceeded the flow of democracy and civil liberties and the flow of oil in the opposite direction notably surpassed the flow of information and cooperation.

Once again, this should be seen as pattern-dynamic view, not political. We can substitute Aspirinia and Ibuprophenia for East and West.

4. Final state. It is in the future and impossible to visualize, but history tells us that war always ends with peace and, unfortunately, *vice versa*. The question is: will the level of stress in the final state be higher or lower than in the initial state?

The answers to questions of this kind cannot be found in pattern theory. They cannot be found in abstract chemistry, either, because chemistry is overwhelmingly based on the idea of equilibrium. If there is a mathematical source of answers, it is the science of complexity, itself very complex and controversial because the distance between computer simulations of simplified systems and real life is immense. We can refer the reader to the book by Stuart Kauffman :

> Organisms, artifacts, and organizations all evolve and coevolve in rugged, deforming, fitness landscapes (Kauffman, 1995, p.246).
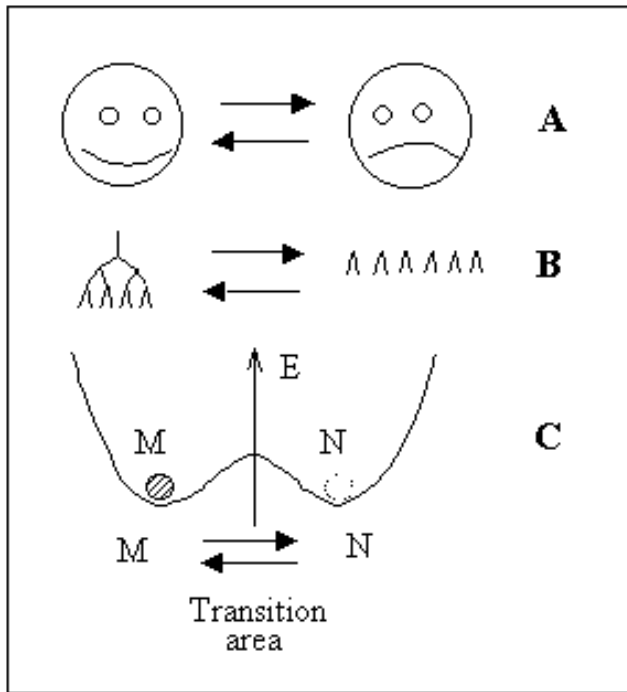
The way we interpret this idea for our purpose is that from any current point we can only list the alternative final states (i.e., patterns) of a complex system but we never know what it is until it is history, passé, over, done with, finished. After that, we are in a new stable state. New and previously unforeseen alternatives of transition state and new final states open before our eyes: the landscape is deformed by our stepping on it over the transition barrier. It is like walking on a waterbed or an inflatable mattress: you make a step, and the surface under and around your feet changes.

A future pattern historian would carefully reconstruct the configurations before and after the conflict, as well as plot the transition state as a sequence of snapshots (as it is done in the war documentary animations), and subtract what remained unchanged, which is most of the picture. Today we, the authors, cannot do it, not only because we are in the middle of an uncertain and fluid situation which is not yet history, but, mostly, because we are a chemist and a mathematician, and not historians, political analysts, and strategic planners. This is why this chapter is so sparsely embellished with points and lines. But we believe that one day somebody can actually draw the picture.

If the picture is simple and clear, the job is done. If it is ambiguous, the enlargement of the picture and a look at the subtracted details may give more accurate evaluation of the bond couple strength. For example, as first approximation, we see Taliban and al-Qaeda as monolith, while a closer look of a historian might reveal internal tensions and rivalry. Future memoirs of American statesmen and generals may disclose the same internal processes in the political and operative planning of the war.

To list the alternative configurations of the final state, we have to look at all the stressed bond couples in the transition state. Some of them may return very close to their initial state, as it

will most probably happen with postal service, healthcare, transportation, and, definitely, with Washington politics. Even the dependence on foreign oil could persist because a very high transition barrier stands on the way of change. What can change more easily is the immigration and visa policy, as well as international relations. This is the easiest part because the partisan legislative wars are less probable on these issues, and for a simple reason: it is not about spending money.

The main potential change that can happen and last significant time is the deformation of the pattern of civil liberties. These are just imaginary examples of a possible *post factum* analysis in a historically distant future.

Figure 28.3. Oscillation between two templates The templates of carelessly open society and its paranoid opposite are completely different. Nevertheless, if their energies are close and the transition barrier low enough, they can convert into each other, Figure 28.3.

Remarkably, the computer simulation of an abstract model (Grenander, 1996, p. 191) shows the reversible transition from one to the other when temperature reaches a certain level. At lower temperature, only one template is trapped in the thermodynamic valley. The experiments of this kind are valid only for a closed system, however. In open non-equilibrium systems, the energy profile constantly changes.

For example, in the future, a global system of monitoring, filtering, and objective measuring of information—the global vital signs—could be installed. It can automatically sound a loud shrill if a similar pattern of escalating terrorism is recorded in measurable units. It could be as mandatory to take certain actions, following the already known historical pattern, as to use a fire extinguisher on a kitchen fire. Unfortunately, this pattern itself is familiar: the former Soviet state security and some Latin American dictatorships used a manual fire extinguisher to put out dissent.

We do not advocate anything like that. It would be a pity to delegate part of human control over human destiny to computers with a mind of their own. But the logic of history tells us that humans would do whatever it takes to sleep quietly on their soft mattresses and not on anything as harsh as the terrain of Afghanistan.

5. Pattern dynamics and metastability.   Metastability of the world (Figure 26.3) is increasing. Nuclear weapon is a typical example of metastability: a slight push on a button releases energy of stellar intensity. From the point of view of thermodynamics, the accidental disaster will happen sooner or later, but "later" is indefinitely far away and "sooner" is tomorrow. This applies not just to the weapon of a possible adversary but also to our own..

Anton Chekhov, the Russian writer of the end of the nineteenth century, who, by the way, sensed a great internal stress in his country long before the Russian Revolution (while Leo Tolstoy did not), said: "If there is a gun hanging on the wall in the first act, it must fire in the last."

Unintentionally, Chekhov invented a metaphor of metastable state. The gun cannot fire on its own, it needs a finger on the trigger, and sooner or later somebody will pull it.   The

rational human behavior is also metastable, and sooner or later somebody will be deranged by the torrent of his own adrenalin.

The accumulation of metastable states is in itself a contemporary pattern and nuclear stockpile is an extreme example. Potential and kinetic energy is being accumulating in taller buildings, faster and larger planes, larger and heavier cars, larger oil tankers, guns in private possession, oil and gas storages, and even in the woods surrounding the houses in the suburbs. Moreover, it is accumulating in masses of people who live in poverty and with the sense of injustice.

It is not generally recognized that biological weapon also uses the energy stored in human body. Bacteria feed on nutrients inside the body. Viruses, in addition, use the enzymatic apparatus of the host. From a distant pattern perspective, terrorism, whether of Timothy McVeigh or Osama bin Laden brand, is a social mutation. What is its internal code?

6. Instability of human mind. Goethe, who described the human chemistry between two couples (Chapter 20, *Probability and energy*), wrote one of the most influential books of the period of Romanticism in Europe: *The Sorrows of Young Werther* (1774). The love of the young man Werther to Lotte, a betrothed woman, ended with Werther's suicide because his love was rejected.

Goethe, who was 23 at the time, woke up famous next morning and his novel became not only an international bestseller, but initiated a wave of commercialization of all things à la Werther. An epidemics of suicides of young men followed.

This example illustrates the catalytic power of ideas.

The simple pattern of self-elimination of one of two disconnected human generators was repeated in scores of other books of that period. Unfortunately, the pattern of eliminating the object of love, that of Desdemona and Carmen, does not even need any catalyst.
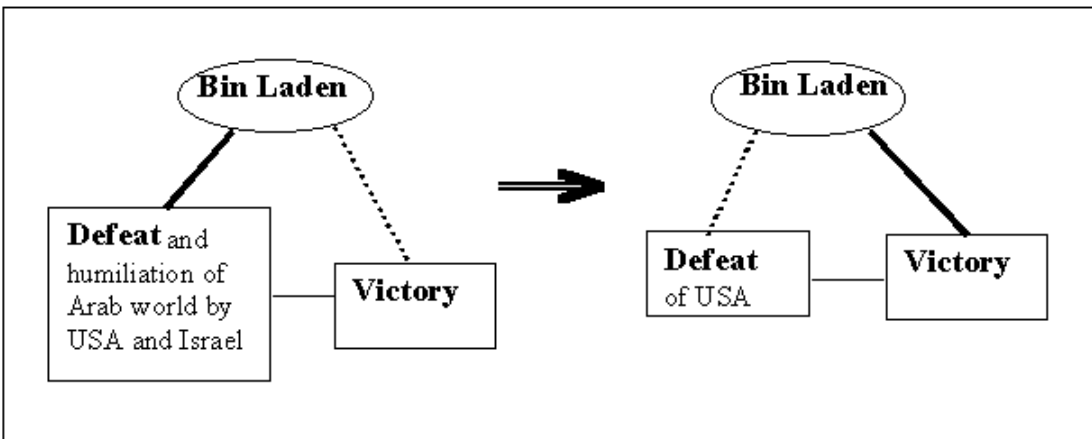
Figure 28.4. Another easy switch in an inflamed imagination

It comes as a surprise of our postmodern era that the extreme patterns of human personality are still little explored by science.

 We have mentioned, half seriously, a possible pattern shift in Hitler's mind in Chapter 22, *Three World Wars*. It can be applied also to the major protagonist of the war against terrorism: Osama bin Laden, Figure 28.4. A thesis and its negation are always topological neighbors. As Randall Collins noted, new philosophic doctrines are formed from the old blocks and their negations. (Collins, 1995). Idea and its negation, thesis and its antithesis, victory and defeat are always close in the mind and the bond couple can swing from one position to the other, as a pendulum, confusing the border between reality and dream.

Understanding the enemy might work better than demonizing him. The age of social psychology could come next after the age of molecular biology and financing psychological research might be a good investment into national security.

Americans were shocked by the suicide mission of the terrorists, not all of whom were destitute people. The mass suicide of the Heaven's Gate cult and the murder-suicide of the Columbine High School had been forgotten.

If there is a gun on the wall, it will fire. If there is a pattern, it will spit out a configuration.

7. Is prediction possible? As we have seen, specific predictions rarely come true. There are very few things we can predict with certainty about large and complex systems. They are of thermodynamic nature, and of no immediate use because thermodynamics is beyond time. On the contrary, kinetics is about time, but it is applicable only to known structures.

Does it mean that a more distant future cannot be predicted in principle? Yes, it can if we see a pattern of a larger scale, on a higher level of abstraction, but with a limited range of transformations, i.e., alternative configurations. What we gain is that instead of the branching tree of alternatives in a sequence of detailed patterns, we have a more manageable list with just a few. The more abstract the pattern, however, the little use of it today, especially in hedonistic societies which care little about future generations.

We are not sure whether God casts a dice. Non-equilibrium thermodynamics certainly does. But we still can rig the dice.

8. Is there anything new under the sun? The pattern of the conflict are, therefore, familiar. There is another discernible pattern, however, which may be a historical novelty of the

late twentieth century: a charismatic and gifted private person, not elected and not acting on behalf of any government or nation, in charge of a financially powerful corporation, single-handedly, inflicts a large scale disaster across national borders, as George Soros is believed to have caused the downfall of Thailand currency in 1997. The fall of the Twin Towers seems to follow the same historically new pattern.

Taking the second snapshot in April, 2002, we can see the events of September 11 already taking up a patina of history. Instead, a new high energy transition state in the Middle East, which was initiated much earlier and independently, brings all the involved participants in the situation of high uncertainty with a multitude of possible final states discussed by an army of political analysts, as well as government advisers, experts in history, culture, and psychiatry, and talk show hosts. The least expected expert to see on the podium is a natural scientist, least of all, a mathematician or a chemist, as if we still believed that an invisible supernatural hand moves the nations and people.

CONCLUSION

The major conclusion that was not anticipated when we started this project is that the enormous complexity of the real world studied by humanities can be simplified. It is possible exactly because the systems are so complex: the change always occurs locally, one step at a time, in a sequence of steps. Moreover, if configurations are complex, the patterns are simple. That was a surprising discovery. The overall picture, however, remains more intricate because, in order to evaluate the probabilities of different pathways, we need a wider range of factors to be taken to account. It is still incomparably smaller than the entire picture and comprises the neighborhood of the focal point of change.

In the end, instead of a doctrinal reiteration of main points, we will attempt to answer the question we have already asked on two occasions in Chapters 3 and 17.

Historians and laymen have been speaking about patterns in politics, culture, and history for a long time without any mathematics. Why do we need any dots and lines at all?

First, we shall attempt to formulate how the concept of pattern in pattern theory differs from the common usage of this term.

The dictionaries give us such meanings as model, archetype, specimen, which means a composite of features characteristic of a certain entity. The word pattern in common language means a persisting behavior, form, or property that we can recognize and label as distinct from another pattern. This pattern is defined over a specific group of objects. For example, we can speak about a pattern of evasive behavior, or totalitarian society, or imperial collapse, or patterns of American and French political attitudes. We used to understand pattern as what makes events different, specific, and unique.

In common perception, dictatorship as pattern is the opposite of democracy. In pattern perception, both are structures that have the same pattern elements and can turn into each other at certain conditions. There is neither absolute democracy nor absolute dictatorship as there is no absolute order and chaos. When they fight, we may choose our political allegiance, but if they are in our lab in cages, taken to an X-ray test, we may give them both a pat on the back.

Both democracy and dictatorship are creatures whose pattern bones we can see on the screen: they are made of the same pattern stuff. Thus, the Soviet and Imperial Chinese systems exemplified absolutism, but even they had some elements of feedback and freedom that democracy had, while democracy may harbor pyramids of absolute subordination, charismatic cults, tyranny of party discipline, and obscurantism shielded from the world by iron mini-curtains.

Pattern apparatus, therefore, is a tool of unification rather than classification.

In this we agree with Tyler Volk (1995) who developed with artistic beauty the concept of metapattern casually expressed earlier by Gregory Bateson: "the pattern which connects"

(Bateson, 1980). This concept of pattern, however, is very general. It views as pattern, actually, any general shape, idea, formula, and principle. The same abstract Platonic view of pattern we find in the book by Keith Devlin (1994). Both books present the beauty and universality of patterns in the common sense of the term, but we need to get closer to earth in order to reveal the patterns of mayhem and slaughter and, using David Gress' pun, to jump from Plato to NATO.

Second, we believe that the social function of history is twofold.

Since its ancient mythological predecessor, history has been part of culture and ideology because it provides a corporate—national, ethnic, religious, professional, etc.—identity, inspiration, and value and tells the students what is good and what is bad, whom to love and whom to hate, what is reaction and what is progress, what is disgrace and what is glory, what is oppression and what is joy of freedom, what is white history and what is black history. This is why history as knowledge is revised time and again, itself a part of history as process. It offers a circus for ideological gladiator fights, creates and updates modern mythology, and is always partial.

> Its [history's] properties are well known. It causes dreams, it intoxicates whole people, gives them false memories, quickens their reflexes, weeps their old wounds open, torments them in their repose, leads them into delusions of grandeur or persecution, and makes nations bitter, arrogant, insufferable, and vain (Valery, 1962, p. 114).

David Remnick argues that the collapse of Communism in Russia started with the return of the true history and discarding the falsified one (Remnick, 1993, p. xi).

History in its second role is, ideally, science that asks questions and answers them without moral qualms and prejudices. If it is art, it is the art of inquiry. It regards the subject as natural process where good and bad have no absolute meaning, and what is good for one group can be bad for another, as well as good for both, and what is bad for the goose can be either good

or bad for the gender, or of no consequences whatsoever. This history, ideally, can be no more partial than quantum physics, which does not mean it is free of debate.

There are some current attempts to create this kind of history. We are not qualified to join the debates but another quotation could be to the point.

> The macrohistorical vision of the engine of human history was thus a vision that conformed to an ancient realism about the human condition, namely, that progress had a price, and that human nature had a dark as well as a light side. Rousseau's vision of how evil entered into history was that one man fenced a field and called it his. The macrohistorical vision did not distinguish between the fencer and his fellows; it did not matter who was first; the Neolithic mutation, whose origins were lost in time, was a logical expression of the human need to diversify and produce, but that expression entailed hierarchy, density, suffering, and exploitation (Gress, 1998, p. 545).

Science becomes a collective enterprise of a community of scientists when it acquires a common, concise, and unambiguous language.

If we measure separately the volumes of one gram of hydrogen, sixteen grams of oxygen, and fourteen grams of nitrogen at the same pressure, their volumes will be the same. This statement can be tested anywhere in the world where we can weigh gas and measure its volume.

We are very far from offering such a language in a finished form, but we believe that the pattern approach is worth trying as a possible *contribution* toward history as an objective science of past, present, and future. Geology, which perceives sand as former rock, a rock as future sand, and the present moment as a clash of tectonic plates, is an example of this kind of science. Reductionism, science of complexity, and patterns could be mutually complementary components in such history. Of course, history is unthinkable now without economic and technological aspects of social evolution. We can only guess whether the corporations are quickly becoming the counterparts of kingdoms and principalities of the past and medieval

history repeats as a chess game with a new set of pieces. These days one cannot take over a free nation with impunity, but one can perform a hostile takeover of a corporation. We have no idea whether this will last and where it will bring us.

Third, we would like to stress that patterns are not exactly points and lines but abstract mathematical objects describing regularity of observed objects. On the surface we can see either narrative or diagrams, or a combination of both, or even a movie. All of them are various ways to represent knowledge.

Representations of history, its events, and actors, come in many forms. The written, of course: the storytelling sort like Macauley and Mommsen, the self serving like Caesar's *Gallic Wars*, the tendentious like Tolstoy, and so on. There are also the pictorial representations as in the paintings of Gericault and David. There is the French *Annales* school with its emphasis on everyday life, demographic and economic statistics, represented by Braudel and Le Roy Ladurie.

A pictorial representation certainly brings the viewer closer to the history it depicts. Such paintings can also carry a message in more or less explicit form. What we have in mind is also a representation of history, not in pictures or words, but by logical diagrams, geometry of relations and changes. Hence we use pattern theory as a mathematical tool, but not a numeric one. Mathematics is not only about numbers, its domain of discourse is vastly richer, and our aim has been to illustrate this in the context of history.

Patterns are hidden behind the images and pattern theory studies how they can be inferred from images and configurations and how the reverse process of generating images and configurations from patterns can be done. Points and lines are only visual symbols. Instead of drawing a line between circles labeled "Rome" and "Empire," we can simply say "Roman

Empire," but the line might remind us that Rome was not always an empire, and not forever either, and that between the beginning and the end the line was times thicker, times thinner.

Whether we throw a stone or launch a missile, the laws of Newtonian physics are there. We can toss a pebble without knowing the laws of physics, but for launching a missile we need physics indifferent to who throws what and why.

The Ptolemaic system of celestial navigation based on what was visible in the skies was in use up to 1980, when the satellites made the Global Positioning System possible and the Nautical Almanac, indifferent to the historical dispute between Ptolemy and Copernicus, antiquated. Yet the system of Copernicus had been there for centuries and it was used for the spacecraft calculations when the time came.
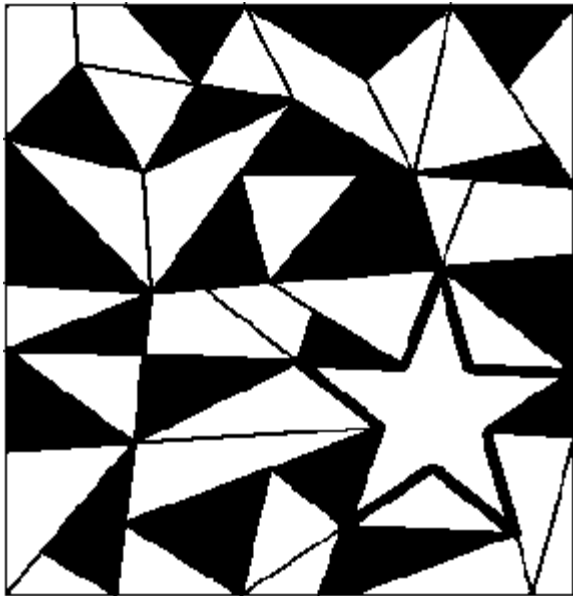
Whether we speak in plain words or draw diagrams and charts, patterns are there. Francis Fukuyama in his *The End of History and the Last Man* argued that "At the end of history, there are no serious ideological competitors left to liberal democracy" (Fukuyama, 1992, p. 211). Yet skeletons of patterns considered gone forever are waiting, in the closets of nations, to be called, clad in flesh and armor, into the fighting ring.

Figure C.1. The star found

It is to the plain words that the traditional historical narrative owes its everlasting appeal and power. We can discuss all our history in plain words but we can probably do more—we do

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not even know how much—if we develop a certain conceptual apparatus indifferent to names, places, and flag colors and opened to other sciences.

We placed in the Prologue a visual puzzle (Figure P.2). We give its solution in Figure C.1. Once we see the star, we cannot "unsee it." Hopefully, once we see the skeletons of events with pattern vision, they will always benignly haunt us.

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