APPENDIX A

NEW TESTS FOR MORPHIC RESONANCE

There are two approaches to testing the hypothesis of formative causation: first, through morphic fields, which connect together parts of a morphic unit in *space;* second, through morphic resonance and its cumulative influence in *time*.

Research on the spatial aspect of morphic fields has been concerned mainly with social and perceptual fields. I have summarized the findings in my books *Seven Experiments That Could Change the World, Dogs That Know When Their Owners Are Coming Home,* and *The Sense of Being Stared At*.[1] The full texts of my scientific papers on these subjects, published in peer-reviewed journals, are available on my website, www.sheldrake.org.

In this appendix, I suggest a range of new tests for morphic resonance itself. When new morphic fields first come into being, they are weak. They are not stabilized by morphic resonance from similar past systems. The more frequently a morphic process occurs, the greater the morphic resonance, the stronger the morphic field, and the more compelling the force of habit. As morphic resonance increases, morphic processes become faster, and morphic fields more stable. These predictions of the hypothesis of formative causation are testable in a wide range of systems, ranging from low-temperature physics to human learning.

A.1 Bose-Einstein condensates

When morphic units have occurred for billions of years and been repeated innumerable times, no changes in the rate of their formation will be detectable. Nor will their stability change. Their habits are fixed. For example, the formation of hydrogen atoms, methane molecules, and sodium chloride crystals will not show any measurable changes. In order to detect morphic resonance, it is necessary to study *new* self-organizing systems.

In the realm of physics, what processes observable here on Earth are unlikely ever to have occurred anywhere else in the universe? Phenomena at very low temperatures.

The background temperature of the universe, as revealed by the cosmic background microwave radiation, is 2.7°K, or in other words 2.7 degrees C above absolute zero. But in laboratories, it is now possible to cool systems to less than 1°C above absolute zero, far colder than the rest of the universe, as far as we know. At these ultra-low temperatures, physical systems behave very strangely.

The best-known low temperature phenomenon is the formation of Bose-Einstein condensates, a new state of matter, over and above the familiar solid, liquid, gas, and plasma states. Satyendranath Bose and Albert Einstein first predicted the existence of these condensates in 1927. The first to be investigated was helium-4 in 1938. When cooled to 2.17°K, it became a superfluid, flowing without friction. The first "pure" Bose-Einstein condensate was made in 1995, with rubidium-87. Such condensates have many strange properties and are effectively superatoms, groups of atoms that behave as one.

Presumably Bose-Einstein condensates made in modern physics laboratories are entirely new to nature, and have never occurred before in the history of the universe (unless they have been made in physics laboratories by aliens on other planets). Since they behave as unified wholes, they may be a point at which quantum fields and morphic fields converge.

If Bose-Einstein condensates are indeed organized by morphic fields, then the more often a given kind of condensate is made in a laboratory, the easier it should be to make it under similar conditions all over the world, and the more stable it should be.

To test for morphic resonance, a new kind of condensate is prepared, and then made again repeatedly under standard conditions. The rate at which it forms is monitored. If morphic resonance is at work, the condensate will form more readily the more often this process is repeated, and the stability of the condensate will increase.

A.2 Melting points

As discussed in chapter 5, morphic resonance should lead to an increased rate of crystallization the more often a compound is crystallized. Through resonance from previous similar crystals, the field of any particular type of crystal should be strengthened.

An increase in morphic field strength should also cause crystals to be more stable; it should be harder to destroy them. Crystals break up when they are heated to their melting point. Morphic resonance should cause the melting points of new kinds of crystals to increase.

This is a shocking prediction. Melting points are called "physical constants" because they are supposed not to change. Although they are affected by a number of variables, such as atmospheric pressure and the presence of impurities, it is generally taken for granted that pure samples of a given substance at standard atmospheric pressure have the same melting point at all times and in all places. Everyone knows that the melting point of ice is, always has been, and always will be 0°C. Weighty handbooks of physical constants list the melting points of many thousands of substances. Few aspects of science seem more certain. Having studied chemistry, I too used to take the constancy of melting points for granted.

After the first edition of this book was published, I gave a seminar on morphic resonance in the Chemistry Department of the University of Vermont in which I discussed the increasing rates of crystallization of new compounds. A chemist pointed out to me that if morphic fields of crystals grew stronger by morphic resonance, then melting points should also rise. He was right. I began to investigate whether this really happened.

I started by asking several synthetic chemists if they had ever noticed a tendency for the melting points of new substances to increase. Yes, they had; this seemed to be a common observation. But they had a ready explanation: as time goes on, chemists' skills improve. Impurities reduce melting points, and therefore melting points rise as chemists make purer samples. I asked, "How we can be sure that the later samples were in fact purer?" The usual answer was: "They must be purer because they have higher melting points." The argument was reasonable, but circular.

I then looked up the melting points of a wide range of organic chemicals in early-, mid- and late-twentieth-century handbooks and chemical journals. My aim was to compare the melting points of compounds that have crystallized in nature for millions of years with those of compounds that first crystallized in laboratories. If there is a general tendency for chemists' samples to be purer, then both kinds of crystals should show similar increases in their melting points. But if melting points are influenced by morphic resonance, only the melting points of recently crystallized substances would be expected to rise. Compounds that crystallize under natural conditions should not show this tendency, for two reasons.

First, there are likely to be limits beyond which melting points can increase no more. Other factors become limiting. This is true of all processes. For example, after Roger Bannister first ran a four-minute mile in 1954, speeds have continued to increase; the current record is 3 minutes 43 seconds. But it is very unlikely that records would keep being broken until the mile is run in 3 minutes, or 1 minute, or 1 second. Other factors become limiting—the muscular system, the ability of the heart to pump enough blood, and even friction—a point would come at which the athletes' jockstraps burst into flames. In general, morphic resonance would be expected to lead to changes that reach limits. And this would be as true of melting points as of everything else.

Second, there will be so much morphic resonance from past crystals that no further change will be observable. Against a background of resonance from quadrillions of past crystals, the resonance from a few thousand more makes no detectable difference.

Obviously the melting points in handbooks are based on reports in the chemical literature that predate the handbooks themselves, and melting points in one edition of a handbook are often copied into the next edition, or copied from other handbooks. Hence the dating of changes in melting points is not precise, and the value quoted in a given handbook could refer to a determination carried out years or even decades earlier.[2] Nevertheless, the handbooks are updated from time to time, and new melting points substituted for old ones.

The most up-to-date melting points are to be found in chemical catalogs. I concentrated on the Aldrich Chemical Company's *Catalogue Handbook of Fine Chemicals*. In many cases, the Aldrich melting points were higher than in the standard reference books in libraries. But how reliable were the Aldrich values? In 1991, I purchased samples of forty different chemicals from Aldrich and arranged for their melting points to be measured in the Materials Department of Imperial College of Science and Technology, University of London.[3] The values were in close agreement with the company's claims, usually with differences of less than one or two degrees C. Thus the melting points in the Aldrich catalog seemed to be a reliable guide to contemporary values.

Many increases in melting points over the course of the twentieth century were greater than five degrees. For example, saccharin, the oldest artificial sweetener, was first synthesized in 1878. In 1902, its melting point was 220°C. By 1996 it was 229°C—a nine-degree increase. Phenolphthalein, used in chemistry laboratories as an indicator of acidity, was first made in 1880. In 1907 its melting point was 252°C; in 1989 it was 262°C—a ten-degree increase. The crown ethers are a family of crown-shaped molecules used as chelating agents, first synthesized in 1976. The most widely used member of the family, 18-crown-6, started with a melting point of 39°C. By 1989, it was 45°C—a six-degree increase.

Other compounds with rising melting points were chemicals naturally occurring in living organisms, but too dilute to crystallize in nature. Although the chemicals themselves have existed for many millions, even billions, of years, they probably crystallized for the first time when they were isolated and concentrated in laboratories from the nineteenth century onward. For example adrenaline, first isolated in 1895, had a melting point of 201°C in 1901. By 1989 it was 215°C—a fourteen-degree increase. Cortisone, isolated in the 1930s from the adrenal cortex, had a melting point of 205°C in 1936; in 1989 it was 225°C—a twenty-degree rise.

In the course of this research I found one glaring anomaly: vitamin B_2, also known as riboflavin, crystallizes in nature, for example, in the eyes of lemurs, and also in some fungal cells.[4] Riboflavin crystals should therefore show little or no change in melting point. Yet there was an increase from 275°C in 1940 to 290°C in contemporary samples. However, the 1940 figure, taken from the fifth edition of the *Merck Index,* was only one of a range of melting points, from 271°C to 293°C, reported between the 1930s and 1950s.[5] This confusing variability may have a simple explanation: riboflavin is now known to have three different crystal forms with different melting points.[6]

In my survey of a wide range of chemicals, I found some with constant melting points and others whose melting points increased. Very few went down. In the early 1990s, I corresponded with the editor of one of the leading handbooks to ask whether he had ever studied the pattern of change from edition to edition. He had not. He was surprised by the widespread tendency for melting points to go up, having assumed that any changes would be a result of random errors, equally likely to go up or down. But this was not the case.

Figure A.1 compares the historical melting points of compounds that have been crystallizing in nature for millions of years with chemical derivatives of these compounds that did not exist until the nineteenth or twentieth century. Salicin is found in the bark of willows, poplars, and in other plants and has been used medicinally since the time of the ancient Greeks. It was first isolated in 1827. Its chemical derivative acetylsalicylic acid, also known as aspirin, was first synthesized in 1853. Aspirin was introduced into medical practice in 1899 and subsequently became one of the world's most popular drugs, with an annual consumption of around 50,000 tons.[7] The melting point of salicin was constant throughout the twentieth century, while the melting point of aspirin increased by eight degrees C.

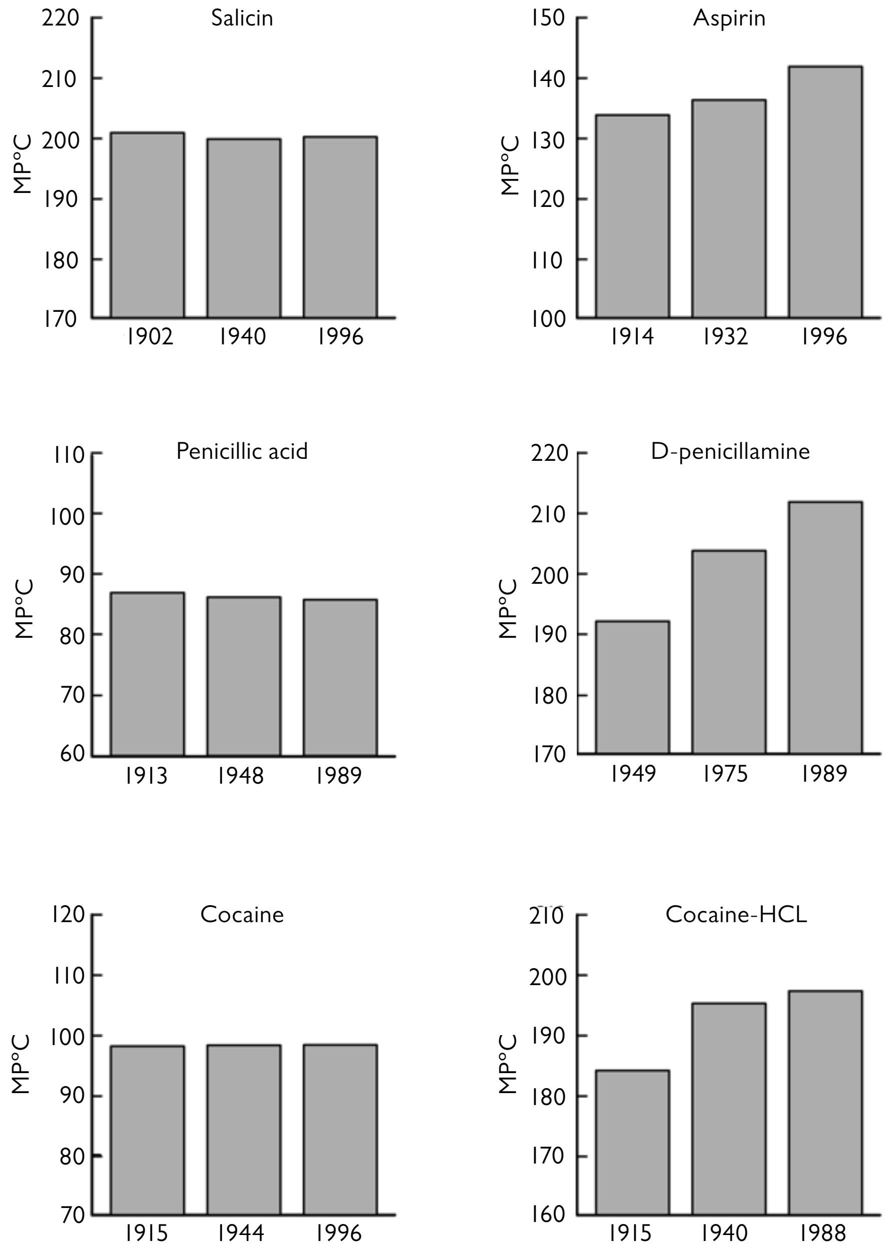

Figure A.1. Changes in melting points over time in natural compounds (left) and related synthetic compounds (right).

Penicillic acid is excreted naturally by several species of fungi in the genus *Penicillium,* and was first isolated and identified in 1913, years before the discovery of the antibiotic properties of penicillin in 1929. A range of related compounds were isolated and synthesized in the 1940s.[8] One of them was D-penicillamine, a breakdown product of penicillin antibiotics, which is used therapeutically as an antirheumatic drug. The melting point of penicillic acid has remained more or less constant, whereas that of D-penicillamine has increased by twenty degrees C.

Cocaine occurs in the leaves of coca plants at a concentration of up to 1 percent.[9] Presumably, over millions of years it has often crystallized as leaves dried up. By contrast, cocaine hydrochloride, the cocaine of commerce, is new; it is produced by treating coca-leaf extracts with hydrochloric acid. The melting point of cocaine has remained constant, whereas that of cocaine hydrochloride has increased by thirteen degrees C.

In 1997, a Dutch Skeptical organization, Stichting Skepsis, wrote to me challenging my observations about changes in melting points. I sent them my data. They checked the literature and came up with very similar values. They conceded that some melting points had indeed increased, but then fell back on the argument that these increases must have been due to improvements in purity rather than to morphic resonance. They had no evidence to support their assumption. In an article they wrote in the *Skeptical Inquirer,* they simply asserted, "There is no other explanation."[10]

Much more research could be done on the history of melting points. I have surveyed only a small part of the huge chemical literature. But unfortunately these records do not usually include any information on purity, and therefore this historical evidence can never be conclusive. The only way forward is to do special tests.

Here is an example. Take six new chemicals recently made in a university or chemical company. Crystallize all six and measure their melting points. Store the samples in a refrigerator. Now, in another laboratory, make one of these chemicals, selected at random, in large quantities, and crystallize it repeatedly. This should lead to an increase in the melting point of this particular compound, but not of the other five. In the first laboratory, now measure the melting points of all six samples again. Does the melting point of the test sample increase? Do the melting points of the other five samples stay the same?

A.3 Crystal transformations

Many chemical substances take more than one crystalline form. The best-known examples are the alternative forms of chemical elements, called allotropes. Graphite and diamond are both crystalline forms of carbon, with the atoms bonded together as a hexagonal lattice in graphite and as a tetrahedral lattice in diamond. Graphite can be transformed into diamond at high temperature and pressure, which is how artificial diamonds are made. Tin has a gray allotrope with a cubic crystal structure and no metallic properties. When heated above 13.2°C, it changes into white tin, which is metallic and has a tetragonal lattice structure. Other elements with allotropic crystal forms are sulfur, phosphorus, and plutonium.

The crystals of many salts and molecules also exist in alternative forms, which are called polymorphs rather than allotropes. For example, calcium carbonate occurs in rocks as calcite or aragonite. Aragonite is more soluble, and occurs as small crystals within basalts, and also in the shells of mollusks. Calcite is found in sedimentary rocks, such as limestone, in Iceland spar crystals, and in the shells of bivalves such as oysters. Aragonite changes to calcite when heated to 470°C.

Potassium nitrate also exists in two alternative forms similar to calcite and aragonite. The aragonite type changes to the calcite type at 127.5°C. The transition has been studied in detail in single crystals slowly heated up and then cooled down while being observed continuously by means of light reflected by the crystals: the polymorphs have different reflection patterns. The aragonite-type crystals took several minutes just above the transition temperature to transform into calcite. When the calcite crystals were cooled down again, the original aragonite structure was restored within a few minutes in surprising detail, with the atoms lined up in the same way they had been in the original crystal, leading the investigators to conclude there was a "memory effect."[11]

Transformations between polymorphs also occur in many crystals of organic chemicals. For example, a sulfur-containing compound called N-methyl-1-thia-5-azoniacyclooctane-1-oxide perchlorate (NMTAOP) has two polymorphs, alpha and beta, with a transition temperature of 17°C. In studies with single crystals, when the alpha form was warmed to a few degrees above 17°C, it changed to the beta form in a few minutes, as measured by the optical properties of the crystals. The reverse transformation occurred when the beta form was cooled to 14°C, but took several days to go to completion. This transformation cycle could be repeated over and over again.[12]

Just as the crystallization of a compound from solution should occur more readily the more often this process is repeated (as discussed in section 5.6), so should the transformation of one polymorph to another occur more readily the more often this polymorph has formed. Hence, crystal transformations could provide a way of testing for morphic resonance.

The transformations need to be monitored continuously, either through optical properties, as in the examples of potassium nitrate and NMTAOP, or by other means: some crystals change color as they transform, while in other cases their electrical or magnetic properties change.[13] The transformations can be brought about by heating or cooling, or by applying high pressure, or by both combined. Do the transformations occur more rapidly under standard conditions the more often a new polymorph is made?

As in the case of melting points, it is important to choose synthetic compounds for this study. Changes would not be expected in the rate of transformation of naturally occurring polymorphs like calcite and aragonite, because they have existed naturally for millions of years; transformations under high pressure and temperature have often occurred within the Earth's crust through geological processes. Fortunately, there are plenty of synthetic organic compounds that have never existed in nature, as far as we know, and whose polymorphs are of recent origin.

A.4 Adaptations in cell cultures

Plant and animal cells can be grown outside the organisms they come from, and some can be propagated in cell cultures within laboratory glassware for years. Through morphic resonance, if some cells from the culture adapt to a new challenge, similar cells should be able to adapt to the same challenge more rapidly even when they are separated.

There is already evidence that such an effect takes place. Miroslav Hill, a cell biologist, made a very surprising discovery in the 1980s when he was director of research at the Centre National de la Recherche Scientifique in Villejuif, France. Cells seemed to be influencing other similar cells at a distance.

Hill and his colleagues were working with cell cultures derived from hamsters. They were trying to find mutant cells resistant to thioguanine, a toxin. The standard procedure was to expose cells to the poison and see if any survived as a result of rare random mutations enabling them to resist it. None did.

At this stage the normal procedure would have been to expose the cells to mutation-causing chemicals in order to increase the number of random mutations and then try again. The conventional assumption is that mutations take place at random; they have nothing to do with adaptation to the environment. Instead, Hill's group decided to follow a trick of the trade of laboratory technicians, not mentioned in official laboratory manuals. Instead of testing large numbers of cells at a single time to find rare mutants resistant to attack, the technicians tested successive generations of cells. At regular intervals they routinely subcultured the cells, taking rapidly growing cells and putting some of them in a fresh culture medium. This process is called a passage. At the time of each passage, they also put some of the cells on top of dying cells in flasks containing the toxin. Sooner or later, resistant cells began to appear.

Hill and his colleagues decided to look for thioguanine resistance using a "serial assay" method, which differed from the technicians' procedure in that fresh flasks of toxic medium were used at each passage.

The hamster cells were grown in a normal culture medium, and while still growing were divided into two samples. One was put into a fresh culture medium so that it could go on growing; the other was put into a new flask of the toxic medium. Thus at each passage, some cells were assayed for thioguanine resistance, while the others went on growing normally (figure A.2).

To start with, all the cells they placed in the thioguanine assay medium were killed. But after several passages, some cells were able to survive in the toxic medium. They had mutated. At the next passage, even more of the cells survived the toxin. The mutation rate was increasing. The descendants of these cells were also able to grow in the toxic assay medium; they inherited this resistance.[14]

Hill and his colleagues did another experiment to see if the same process could be repeated with a different poison, ethionine, not previously used in toxicity studies with hamster cells. For the first thirty passages, over a fifteen-week period, all the cells exposed to ethionine died.

> The subsequent passages were characterized by a sudden appearance of mutants. These were more frequent from passage to passage . . . Thus ethionine-resistant mutants occurred in cultures growing without selection, and arose, in those growing cultures, in response to an ethionine attack on cells in parallel, physically separated cultures.[15]

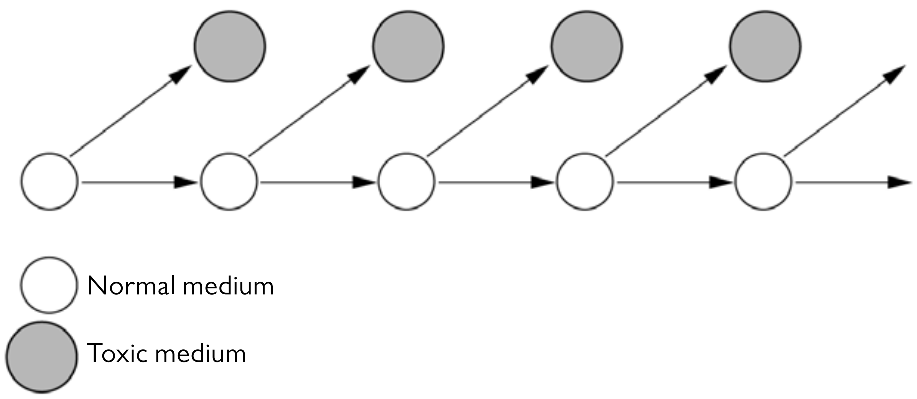

Figure A.2. Miroslav Hill's serial assay technique. At each passage, some cells were transferred to the toxic medium and some to the normal medium.

The ethionine-resistant cells gave rise to descendants that inherited their resistance.

Hill's team then investigated whether the same techniques would enable hamster cells to adapt to high temperatures. The cells were grown, as usual, at 37°C, and at each passage, a sample was withdrawn and assayed for growth at 40.6°C.

> Cells in the first sample died within three days, in the second they survived a profound crisis and gave rise to eleven colonies, and in the third they became established after a barely noticeable crisis. These cells then grew continuously as a cell line at 40.6°C.

In a second phase of the experiment, this cell line was kept growing at 40.6°C and samples were withdrawn at each passage and assayed at 41.3°C. No cells survived at this elevated temperature for thirty-one passages. Then tolerant cells began to occur in small numbers, then more frequently, and finally in large numbers. This new strain could thereafter be grown indefinitely at 41.3°C. In further experiments, Hill's team succeeded in establishing a strain that could grow at an even higher temperature, 42.0°C, but were not able to go higher.

Hill's conclusion was that "cells are more likely to survive an attack if their close relatives have already experienced such an attack." He argued that this showed that "there is an additional flow of information, not mediated by DNA, which may be referred to as adaptive information."

How was this adaptive information transmitted to close relatives? Hill suggested it happened because some of the cells under attack and some of the cells in the normal culture were sisters, separated at the most recent passage. Because they were descendants of the same mother cell, they were "entangled" in the sense of quantum physics.

According to quantum theory, systems that were part of the same system in the past remain linked, even when miles apart, such that a change in one is immediately accompanied by a change in the other, a phenomenon that Albert Einstein described as "spooky action at a distance." There is good experimental evidence that entanglement (also known as quantum non-locality, or quantum non-separability) really happens. Hill suggested that sister cells are not just analogous to but actually are entangled quantum systems.

Hill proposed that some of the cells struggling for survival adapted in such a way that they could resist the toxin, and their entangled sister cells underwent a similar adaptation even though they were not exposed to the toxin. Some of the descendants of these unexposed sister cells were carried over at the next passage to the assay conditions, and when they came under attack they were already resistant. Thus, passage by passage, the proportion of resistant cells increased in cells growing under normal conditions (figure A.3a).

The hypothesis of morphic resonance provides an alternative interpretation. Some cells under attack may undergo adaptive changes, as Hill

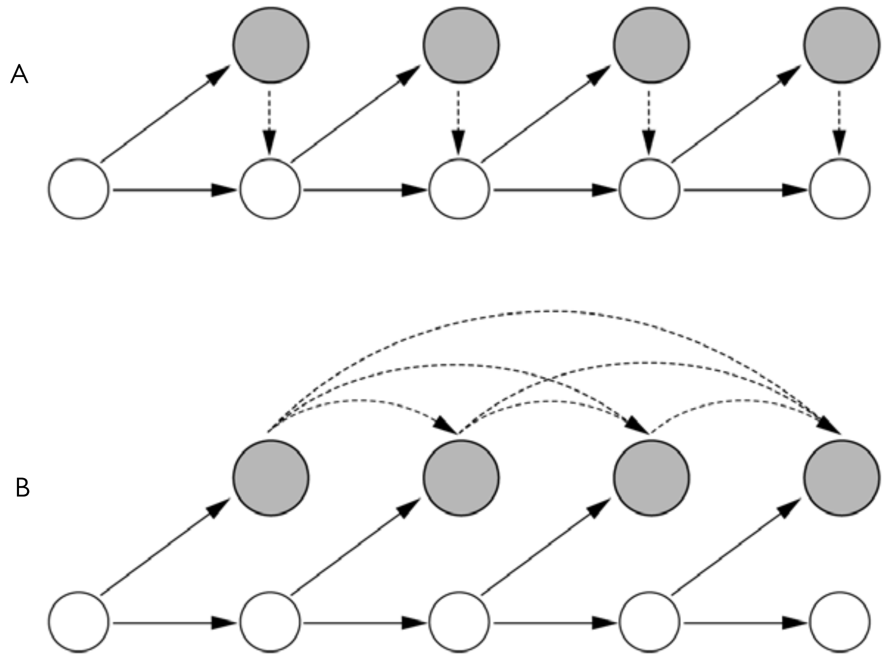

Figure A.3. Above: The "entanglement" interpretation of the Hill effect. Adapted cells in the toxic medium affect their sisters in the normal medium through entanglement (dotted lines). Below: The morphic resonance interpretation of the Hill effect. Adapted cells in the toxic medium influence subsequent cells in the toxic medium by morphic resonance (curved dotted lines).

suggests. Then cells currently under attack tune in to the adaptation via morphic resonance from past cells under attack. Hill's proposal involves a transmission of adaptive information across space, from sister cells under attack to sister cells in the normal culture. Morphic resonance involves a transmission of adaptive information across time, from past cells under attack to present cells under attack (figure A.3b).

These interpretations make different predictions that can be tested by experiment. Mouse cells could be used instead of hamster cells to avoid any morphic resonance from Hill's previous experiments.

Two cell lines, A and B, are derived from a common ancestral culture. Line A is simply transferred to a new normal medium in passage after passage, with no samples subjected to attack. B is subcultured following the Hill serial assay procedure, with some of the cells put under attack at each passage (figure A.4). Say that resistant cells in line B arise at passage five. The entanglement hypothesis predicts that adaptation should increase in the normal cells in line B but not in line A. Starting at passage five, line A is now subcultured at each passage following the Hill procedure, and subcultures are subject to the same attack as those in line B (figure A.4). The entanglement hypothesis suggests that there

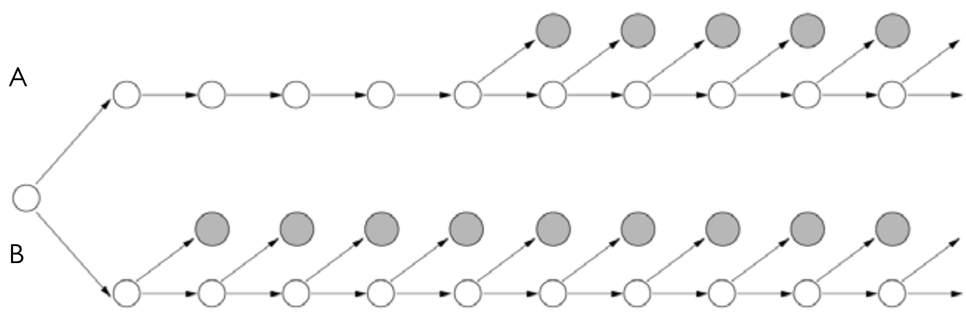

Figure A.4. An experiment to distinguish between entanglement and morphic resonance effects in the adaptation of cells to a toxic medium. Below: At successive passages, cells in line B are placed in a toxic medium. After, say, five passages, adapted cells begin to appear and the proportion of adapted cells increases in subsequent passages. Above: The serial assay procedure begins after five passages in line A. If only entanglement was at work, adapted cells would not appear in the toxic medium for about five passages; if morphic resonance was at work, they would appear almost immediately.

will be about five passages before the cells under attack begin to develop resistance, as before. But the morphic resonance hypothesis suggests that resistance should begin to appear within one or two passages, because of morphic resonance from cells in line B.

A.5 Heat tolerance in plants

Animals and plants often adapt to changes in their environment. For example, humans who move to high altitudes acclimatize through a variety of physiological responses, including making more red blood cells. Sheep moved to cold, damp climates grow thicker wool. Plants moved to new climates adjust their physiology and growth habits.

Gardeners are familiar with these changes, and know that plants grown in greenhouses may need "hardening off" if they are to survive outdoors. The plants are moved to a cold frame and gradually exposed to outdoor conditions during the daytime, then at night, before they are planted out in the open air. Hardening off may take two or three weeks. A range of biochemical changes occurs within the plants and they often grow thicker coatings of wax on their leaves. Under natural conditions, plants undergo cold hardening at the beginning of winter as temperatures drop, helping them to resist damage by frost that kills unhardened plants.

When plants are introduced into new environments by gardeners or farmers, the plants may continue to adapt over several generations. Charles Darwin was convinced that the new habits that plants acquired as they acclimatized were inherited, for example when spring-sown varieties of cereals were planted in the autumn and changed into winter varieties.

> In the reciprocal conversion of summer and winter wheat, barley, and vetches into each other, habit produces a marked effect in the course of a very few generations. The same thing apparently occurs with the varieties of maize, which, when carried from the Southern States of America into Germany, soon become accustomed to their new homes.[16]

Trofim Lysenko and his colleagues in the Soviet Union continued to study the interconversion of winter and spring wheat varieties, and they applied these principles to Soviet agriculture on a large scale, with some success. But the subject became intensely politicized, and neo-Darwinians in the West denounced the findings of the Soviet researchers as bogus.[17] The inheritance of adaptive habits is prohibited by neo-Darwinism; only genes can be inherited.

Darwin was not a neo-Darwinian. In his book *The Variation of Animals and Plants Under Domestication,* he brought together impressive evidence for the inheritance of acquired characteristics. He thought heritable habits played an important part in evolution, along with spontaneous variation and natural selection: "We need not . . . doubt that under nature new races and new species would become adapted to widely different climates, by variation, aided by habit, and regulated by natural selection."[18]

Morphic resonance provides a means whereby habits can be inherited and is in accord with Darwin's own ideas. But however much it agrees with Darwin, it is still only a hypothesis. Does it really play a part in the adaptation of plants to new conditions?

I propose a simple test in which plants of an inbred strain, say a standard variety of pea, are grown from seed in a controlled environment under near lethal high temperatures. The proportion that survives is recorded. The same procedure is repeated again and again. An increasing proportion of plants should survive because of morphic resonance from those that adapted successfully in previous trials.

This experiment could be done with two parallel lines. In C, plants are grown from the original stock of seeds, so there is no possibility that any adaptive changes are passed on through the genes (figure A.5 above). Any increase in adaptation over time would be a result of morphic resonance.

In line D, seeds are taken from plants that have survived the high temperature and are used for growing the next generation (figure A.5 below). In this line, any increase in adaptation from generation to gen-

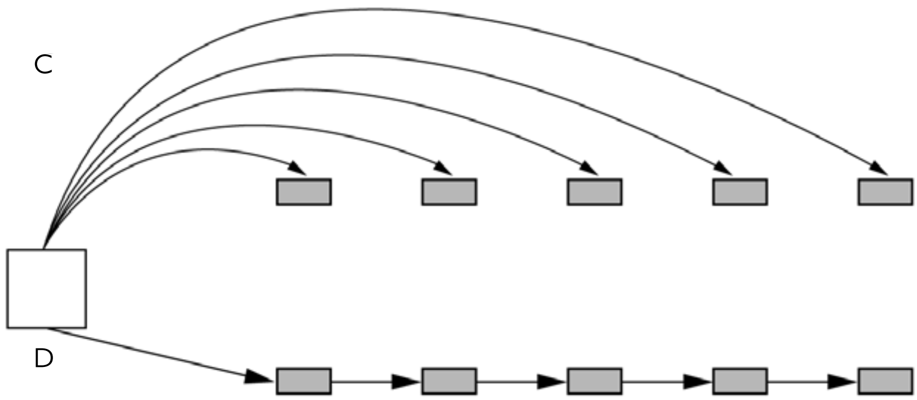

Figure A.5. An experiment on heat tolerance in plants. Above: Seeds of an inbred variety are grown under high temperature conditions in successive trials. If morphic resonance is at work, they should show greater adaptation in successive trials. Below: Seeds taken from heat-adapted plants are used in the next trial. Increased heat adaptation in successive generations could be due to a combination of epigenetic inheritance and morphic resonance.

eration would be due to a combination of morphic resonance and epigenetic inheritance.

The recognition of epigenetic inheritance took place only after the turn of the millennium, and it provides a legitimately mechanistic basis for the inheritance of acquired characteristics. Now that a mechanistic explanation is available, the taboo against the inheritance of acquired characteristics has been lifted (section 7.7). Evidence for the inheritance of acquired characteristics that was previously anomalous and rejected or ignored has been rehabilitated.[19]

If heat adaptation has heritable epigenetic effects, the progeny of adapted plants will tolerate high temperatures better than plants grown from the original batch of seeds (figure A.5). Epigenetic inheritance will not only pass on patterns of gene activation and inactivation but also, at the same time, make the progeny of adapted plants more similar to previous adapted plants, and hence more strongly affected by morphic resonance from them. Any improvements in the adaptation of plants in line D would be a result of both direct epigenetic inheritance and increased morphic resonance.

The conventional expectation would be that line C would show no change. The hypothesis of formative causation predicts that both lines C and D will show a progressive heat tolerance in successive trials, but line D will show this effect more strongly.

A.6 The transmission of aversion

Conditioned aversion is a rapid and long-lasting form of learning. Animals avoid eating something that has made them ill. If you eat a new kind of food and are sick soon afterward, you will probably avoid that food thereafter. Conditioned aversion occurs in invertebrates, too. Its evolutionary advantages are obvious—it helps animals avoid harmful foods, and hence survive better.

Conditioned aversion is associated with the brain stem, the part of the brain that helps control the gut, the secretion of gastric juices, and vomiting. Learning at this level operates unconsciously. If a cancer patient receives chemotherapy that makes her feel sick, and eats something just before the sickness starts, she will probably find its smell nauseating for the rest of her life, even though she knows that the cancer treatment and not the food was the cause of her illness. Conditioned aversion overrides conscious understanding.

Could conditioned aversion be transmitted by morphic resonance? If animals of a particular species have become averse to eating a harmful kind of food, will animals of the same species tend to avoid that food as a result of morphic resonance from similar animals that have already become averse to it? Some preliminary experiments suggest this might happen.

In 1988, I wrote an article about morphic resonance in the *Guardian,* a British newspaper. Soon afterward the same newspaper published a response by Steven Rose, a neuroscientist, who challenged me to test “this seemingly absurd hypothesis” in his laboratory at the Open University. Rose was well known in Britain for his strong political views—he was a Marxist—and his robust polemical style.

I accepted his challenge, and raised the funding for the tests to be carried out by a student, Amanda Harrison, in Rose's laboratory. She worked under Rose's supervision and was not informed of the hypothesis being tested.

At that time, Rose was studying changes in the brains of day-old chicks as a result of conditioned aversion. Chicks instinctively peck at small bright objects in their environment, and Rose's standard procedure was to expose chicks to a test stimulus, for example a small yellow light–emitting diode (LED). Soon after the chicks pecked it, they were made mildly sick with an injection of lithium chloride. As a result, they developed an aversion to pecking the same kind of bead again. Control chicks were exposed to a control stimulus, say a chrome bead. After pecking at the chrome bead, the control chicks were injected with a harmless saline solution, and developed no aversion to it. This form of learning was different from conditioned taste aversion in that it involved a visual stimulus, but like taste aversion it provided a rapid form of learning that needed only one trial.

Rose and I designed an experiment with a new stimulus, a yellow LED not previously used in experiments of this kind, to avoid any carryover of morphic resonance from previous aversion experiments with green LEDs. Indeed, we found that the chicks pecked a yellow LED much more readily than a green LED: there was an average delay of 4.1 seconds before they pecked the yellow LED and 19.0 seconds with green.[20] For the control stimulus, we used a chrome bead.

Every day for thirty-seven days the same tests were performed with fresh batches of day-old chicks. Half the batch of chicks, selected at random, was tested with the yellow LED, the other half with the chrome bead. Then the chicks exposed to the yellow LED were made mildly sick. Three hours later they were tested again, and exposed to both the yellow LED and the chrome bead. Most avoided pecking the yellow LED, but had no aversion to the chrome bead. The control chicks that had pecked at the chrome bead were injected with saline solution, and they too were tested three hours later with both the chrome bead and the yellow LED.

I predicted that if morphic resonance was taking place, successive batches of day-old chicks should show an increasing aversion to the yellow LED when first exposed to it. No such aversion to the chrome bead would be expected with the control chicks. Rose predicted that there would be no increase in aversion with the control *or* the test chicks.

What did the data show? First of all, there was an effect that neither of us had predicted, though in retrospect we should have done so. The student carrying out the tests had never worked with chicks before, and took about a week before she learned how to handle the chicks and carry out the tests properly. The data from the first few days showed a big learning effect—not by the chicks but by the student. From then on, after she had learned the techniques, there was a consistent pattern. Relative to the controls, the test chicks exposed for the first time to the yellow LED became progressively averse to pecking it (figure A.6). This effect was statistically significant.

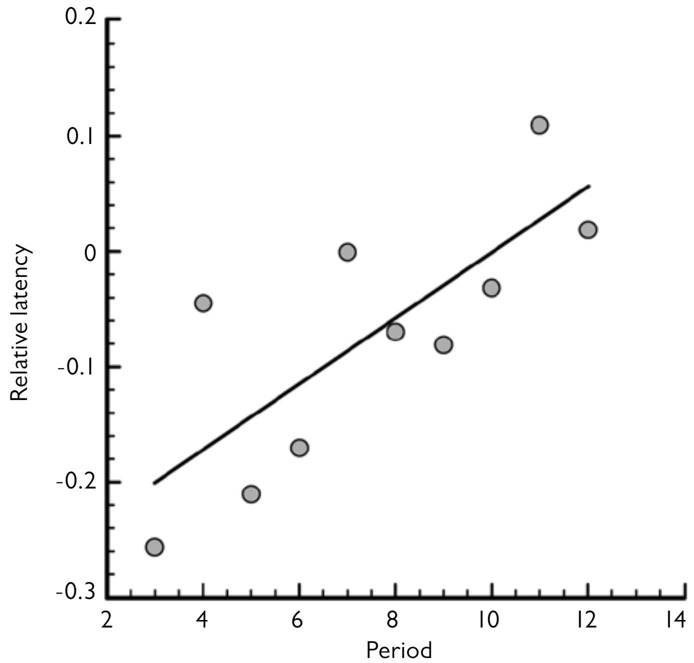

Figure A.6. An experiment on conditioned aversion with day-old chicks. "Test" chicks were exposed to a yellow light–emitting diode (LED) and control chicks to a chrome bead. There was an increased delay in pecking at the LED relative to the control stimulus in successive three-day periods. The measure of delay, or "latency," was the proportion of chicks that did not peck at the stimulus within ten seconds. (Data from Sheldrake, 1992a)

In my view, the data were consistent with the operation of morphic resonance. In Rose's view, they were not.[21]

Perhaps the best opportunity for further research on the transmission of aversion is with rats. Conditioned aversion is an important practical problem for the rat-control industry. If rats are fed bait laced with a quick-acting toxin, the poison kills a few rats to start with, but the other rats soon avoid it. They rapidly become "bait shy." For this reason, the most effective rat poisons are slow-acting, like warfarin, which does not cause illness soon after being eaten. Warfarin, first licensed for use as a rodenticide in 1952, is an anticoagulant and works slowly because it kills rats through internal bleeding. Some bleed to death after being bitten by other rats.

After warfarin had been in use for about ten years, resistant strains of rats began to appear in Britain, then in other parts of Europe, the United States, and Asia. In the 1970s, poison manufacturers rose to the challenge by producing a second generation of rodenticides, "superwarfarins" such as brodifacoum. Resistance to these new toxic agents is now increasing all over the world.[22]

When anticoagulant poisons fail to eradicate all the rats in an infestation, pest-control operatives usually revert to using a fast-acting, old-style rat poison like zinc phosphide. Because rats so rapidly become bait shy, a technique called prebaiting is used. The rats are fed on an attractive food that does not contain poison and when they are used to it, zinc phosphide is added. The rats are no longer cautious and eat enough to kill them.

Without prebaiting, individual rats may eat only a small amount of poisoned bait. They fall ill but then recover and are bait shy because of conditioned taste aversion. Rats are social animals, and bait-shy individuals communicate their aversion to other members of the group by "social learning." One component of social learning is imitation, especially the imitation of parents by their young. Another component is the smelling of the breath of other members of the colony, enabling other rats to know what they have been eating. Morphic resonance may also play an important role in social learning. But as bait shyness spread through a colony, it would be impossible to tease apart the relative contributions of morphic resonance and other kinds of information transmission. To test for morphic resonance, it would be necessary to compare the behavior of separate colonies miles apart.

Here is a simple experimental design. Two new kinds of food, designated G and H, are given unusual flavors that rats are unlikely to have encountered before. Ten colonies are selected for this experiment, located miles away from each other. Five of these colonies are selected at random and both G and H are made available to them. The rates at which the rats eat them are recorded. Now one of the foods is selected at random—say G—and poisoned with low doses of zinc phosphide. The rats become bait shy and avoid G.

Now rats in the other five colonies are given unpoisoned G and H to eat. If morphic resonance is at work, the rats should show a tendency to avoid G but not H.

Similar experiments could be done under more-controlled conditions with captive colonies of rats or mice, but to minimize unnecessary suffering, it would be better to do these experiments in situations where the animals are going to be poisoned anyway.

A.7 The evolution of animal behavior

In *The Presence of the Past,* I described the spread of a new pattern of behavior suggestive of morphic resonance: the stealing of cream by blue tits. In Britain, fresh supplies of milk were (and still are) delivered to the doorsteps of houses every morning except Sunday. In the 1920s, blue tits and several related species of birds began to steal cream by removing the caps and drinking from the tops of the bottles.

The first record of this habit was in 1921 from Southampton, and its spread throughout Britain was monitored by amateur bird-watchers between 1930 and 1947. The main cream-stealing species were blue tits, great tits, and coal tits. Once cream-stealing had been discovered in a particular place, it spread locally by imitation.

Tits do not usually move more than a few kilometers from their nesting place, and appearances of this habit over gaps of more than twenty-five kilometers probably represented new discoveries by individual birds. A detailed analysis of the records by scientists at Cambridge University showed that cream-stealing was probably discovered independently at least eighty-nine times in the British Isles. The spread of the habit accelerated as time went on.[23]

This habit also appeared in continental Europe, particularly Sweden, Denmark, and Holland. The Dutch records are particularly interesting. Milk deliveries stopped during the Second World War and began again in 1947. Tits live only a few years, and probably none that had learned this habit before the war would have survived until this date. Nevertheless, attacks on milk bottles began again rapidly. "It seemed certain that the habit was started in many different places by many individuals."[24]

Incidentally, cream-stealing now seems to be dying out. In the late 1980s, tits regularly attacked milk bottles delivered to our family house in London. In the early 1990s, we switched from full-cream to semi-skimmed milk, like many other people, and the attacks soon stopped. I have not seen a milk bottle attacked by tits for more than ten years, although there are still plenty of tits in the neighborhood. The birds seem to have given up now that there is so little cream to steal.

Several other examples of the rapid evolution of new patterns of behavior suggest morphic resonance could have played a part.

According to an eminent Texas naturalist, Roy Bedichek, when barbed wire was first introduced, in the late nineteenth century, skeptics predicted that it would never be suitable for horse pastures. Horses dashed right into it and "cut their own throats, tore great slugs of flesh from their breasts, while wounds not fatal or mere scratches became infested with screw worms." In 1947 he wrote, "I can remember the time when there was hardly a horse to be found in Texas farming or ranching sections that was not scarred from encounters with barbed wire."[25] Yet by the middle of the twentieth century, this was now no longer a serious problem: "In half a century the horse has learned to avoid barbed wire. Colts rarely dash into it. The whole species has been taught a new fear."

Bedichek also commented on the changed reactions of horses to cars.

> When automobiles first appeared, horse-drawn traffic was disorganized. The more considerate autoist would drive out of the road and cut off the motor immediately a team of horses hove in sight. Not only that, the motorist would get out of his car and help the driver lead the rearing, snorting horses by it. Many the vehicle wrecked and many the neck broken in making the introduction of horse to automobile and establishing his tolerance for it. Loud were the demands for laws to keep automobiles in their place . . . We no longer have breakneck runaways every time a team of horses meets an automobile.[26]

Another example of behavioral evolution in farm animals concerns cattle grids (known as cattle guards in the United States), which are pits with a series of parallel steel tubes or rails over the top. They make it physically impossible for cattle to walk across them, and serve as both a gate and a fence; they keep livestock from passing, but allow vehicles and people to cross freely. Cattle guards were invented in the United States in the nineteenth century to stop animals wandering onto railway lines. They began to be used on American roads around 1905,[27] and are now widely used in many other countries.

When cattle grids were first introduced, animals may have had to learn the hard way that they could not pass. But this is no longer the case. Farm animals seem to avoid these grids instinctively and do not even try to cross them.

Several decades ago, ranchers throughout the American West found that they could save money on cattle grids by using fake grids instead, consisting of stripes painted across the road. The painted grids worked because the animals did not even try to cross them.

In response to my inquiries, several ranchers in the western United States told me that there is no need for herds to be exposed to real cattle grids first. Animals that have never seen a real cattle grid avoid the fake ones. When young cattle approach a painted grid, they "put on brakes with all four feet," as one rancher expressed it. I corresponded with researchers in the Departments of Animal Science at Colorado State University and at Texas Agricultural and Mechanical University (A&M) who confirmed this observation.

Professor Ted Friend, of Texas A&M, systematically tested the responses of several hundred head of cattle to painted grids, and found that naive animals avoided them just as much as those previously exposed to real grids. Sheep and horses also showed an innate aversion to crossing painted grids. Nevertheless, the spell of a fake grid could be broken. When cows were driven toward one under pressure, or when food was placed on the other side, sometimes one of them examined the stripes closely and then walked across. When one member of a herd did this, the others soon followed. Thereafter, the phony grid ceased to act as a barrier.[28]

Perhaps painted cattle grids work simply because they create the illusion of a drop. In this case, they should have worked all along, and ranchers need not have used real grids in the first place. It would be interesting to find out if *wild* species never before exposed to cattle grids show a comparable aversion to crossing them. It would also be good to find out whether cattle respond equally well to a variety of striped patterns, or just stripes that look like cattle grids.

Interestingly, a new response to cattle grids is currently evolving. In 1985, sheep near Blaenau Ffestiniog, in Wales, started escaping from their pastures by rolling over grids. So did sheep in Sweden, around Malmohus. An editorial in the *Guardian* in 1985 commented:

> To the best of our knowledge the sheep in the Yorkshire Dales, which are mostly Swaledales or Dalesbred, have yet to master the technique of crossing cattle grids by curling up and rolling over them. Yet the sheep of Blaenau Ffestiniog, which are a different breed, have learned how to do it (to the annoyance of the town, which may have to put up a fence) and so have the lowland sheep of southern Sweden. Among the questions that immediately arise are how long will it take the Swaledales to learn and whether, when they do, they will be demonstrating the theory of formative causation.[29]

Twelve years later, sheep started crossing cattle grids in Hampshire. To start with, they used a "commando" technique, with one of them lying on the cattle grid while others scrambled across her. But then they started crossing by rolling across the bars of the grid, like the Welsh sheep.[30] Similar behavior was observed in the Valais region of Switzerland.[31]

In 2004, nineteen years after the editors of the *Guardian* had anticipated the possibility, sheep on the Yorkshire moors began escaping from the moors by rolling over cattle grids and grazing on the nearby gardens of villagers.[32]

Animals, both wild and domesticated, continue to evolve in response to man-made changes in their environment, and the emergence of new patterns of behavior provides opportunities for documenting how these patterns spread. The monitoring of cream-stealing in Britain by amateur bird-watchers in the 1930s and 1940s provides a good precedent for research with widespread participation. Such studies will never be able to provide such clear-cut data as laboratory experiments, but they could shed light on the possible role of morphic resonance in evolution, with very different implications from the neo-Darwinian theory.

A.8 Collective human memory

According to the hypothesis of morphic resonance, that which has been learned by many people in the past should be easier for people to learn today. Everyone draws upon and in turn contributes to a collective human memory.

In 1982, the British magazine *New Scientist* held a competition for ideas for tests of morphic resonance. The winning entry was by a psychologist, Richard Gentle, for an experiment involving Turkish nursery rhymes. He suggested that English-speaking people be asked to memorize two short rhymes in Turkish, a traditional nursery rhyme known to millions of Turks over the years and the other a new rhyme made by rearranging the words in the genuine nursery rhyme. The participants would not be told which was which. After equal periods spent memorizing each of the rhymes, they would be tested to find out which they remembered better. If morphic resonance were at work, the traditional rhyme would be easier to memorize than the new one.

This is an example of an "old field" test, whereby learning of something with a long-established morphic field is compared with learning something new. Many old-field tests of morphic resonance have been conducted. Most have given positive results.

I took up Gentle's suggestion but used Japanese rather than Turkish nursery rhymes. A leading Japanese poet, Shuntaro Tanikawa, kindly supplied me with a genuine nursery rhyme known to generations of Japanese children and two others specially composed to resemble it in its structure, one meaningful and the other meaningless. In tests conducted in Britain and America, people did indeed remember the genuine rhyme significantly better than the others.[33] But this experiment raised a difficulty that applies to all old-field experiments. How can one be sure that the new rhymes, with which the old one was compared, were of similar intrinsic structure? Perhaps real nursery rhymes became popular precisely because they have features that made them easier to memorize in the first place. Although a poet is more likely to be able to produce comparable new rhymes than an amateur, it is hard to know whether the new rhymes would be intrinsically comparable to the old ones in the absence of any morphic resonance effects.

Most old-field tests have involved foreign scripts. Gary Schwartz, a professor of psychology at Yale University, carried out one of the first. His idea was that ordinary words should be associated with morphic fields that facilitate their recognition. For example, the English word *cat* is recognized as a whole—as a Gestalt—and involves a morphic field sustained by resonance from millions of readers in the past. By contrast, a meaningless anagram of the same letters, like "tca," has no such resonance. Schwartz reasoned that people who are unfamiliar with a foreign script might find it easier to recognize real words in this language than false words.

Schwartz selected forty-eight three-letter words from the Hebrew Old Testament, twenty-four common and twenty-four rare, and then produced a meaningless anagram of each word, giving ninety-six words in all. Over ninety participants who were ignorant of Hebrew were shown these words one by one, projected on a screen in a random order. They were asked to guess the meaning of each word by writing down the first English word that came to mind. Then they estimated on a 0–4 scale the confidence they felt in their guess. They were not told the purpose of the experiment, nor that some of the words were scrambled. This test depended entirely on the visual pattern of the written words; it did not involve hearing the words or attempting to pronounce them.

A few participants did in fact guess the meanings of some of the Hebrew words correctly, but Schwartz excluded them from his analysis on the grounds that they might have had some knowledge of Hebrew. He then examined the replies of the participants who always guessed the wrong meanings. Remarkably, on average, they were more confident about their guesses when viewing real words than scrambled words, even though they did not know that some of the words were real and others false. The effect was roughly twice as strong with the common words as with the rare words. The results were very significant statistically.[34]

Only after Schwartz had tested his participants did he inform them that half the words were real and the other half were scrambled. He then showed them the words again, one by one, asking them to guess which was which. The results were no better than chance. The participants were unable to do consciously what they had already done unconsciously. Schwartz interpreted the greater confidence participants felt about their guesses of the meanings of the real words in terms of an "unconscious pattern recognition effect."

Alan Pickering, a psychologist at Hatfield Polytechnic in England, used Persian words rather than Hebrew words, written in Persian script. His test, like Schwartz's, involved real and scrambled words. Participants were shown a word and asked to look at it for ten seconds. They were then asked to draw it. Independent judges evaluated the reproductions of real and false words. Neither the experimenter nor the judges knew which words were real and which were scrambled. The real words were reproduced significantly more accurately than the false words.

Subsequent experiments carried out as student projects by Nigel Davidson with Persian words and by Geraldine Chapman with Arabic words gave similar positive results.

Arden Mahlberg, an American psychologist, performed an analogous test with Morse code. He constructed a new version by assigning dots and dashes to different letters of the alphabet. The participants did not know Morse code. He compared their ability to learn the new code and genuine Morse code, presenting the material in a written form. (The letters *S* and *O* were excluded because many people who do not know Morse code are nevertheless familiar with the code for S.O.S.) On average, participants learned real Morse code significantly more accurately than the new code.[35]

Suitbert Ertel, a professor of psychology at Göttingen University, Germany, investigated the possible effects of morphic resonance on the recognition of Japanese hiragana script, a phonetic component of the Japanese writing system. Participants were shown nine different hiragana characters in a random order, projected on a screen for eight seconds. They then turned to an answer sheet with twenty hiragana characters, among which the nine characters they had just seen were randomly mixed. They were asked to mark the characters they thought they had just seen. The same test was repeated with the characters in different random orders. Each participant did six trials, and the recognition of the hiragana characters generally improved trial by trial.[36]

Ertel predicted that if morphic resonance were playing a part, hiragana characters should be recognized more readily when they were the right way up than when they were upside down, because millions of Japanese were used to recognizing these characters in their normal position. Sure enough, this is what he found.

In a further experiment, he used artificial hiragana characters invented by a graphic designer. Before running the learning tests, he and his students showed participants genuine and artificial hiragana characters and asked them to pick the genuine ones. They could not tell the difference. The Göttingen team then carried out its standard memory tests, and found that the real characters were remembered better than the false ones, in accordance with the predictions of the hypothesis of morphic resonance.

Ertel and his team then carried out a further test, which they regarded as crucial. They compared the effect of putting the real characters upside down with that of putting fake characters upside down. Ertel argued that with fake Hiragana characters, rotation should have no effect because morphic resonance plays no part in the recognition of these characters either way up.

The results were confusing and Ertel's interpretation was hard to follow. In the first two trials, there was indeed almost no difference in the recognition of the upside-down and right-way-up fake hiragana characters (figure A.7). But in the subsequent trials, the false hiraganas were remembered better the right way up. Ertel argued that the faster rate of learning in the later trials with the fake hiraganas the right way up was because of "intrinsic factors" that had nothing to do with morphic resonance. Surprisingly, he provided no statistical analysis to show whether this effect was significant.

However, Ertel's fake hiragana characters were *designed* to look like real hiragana characters when they were the right way up. Insofar as they resembled real hiragana characters, it may be that they did so

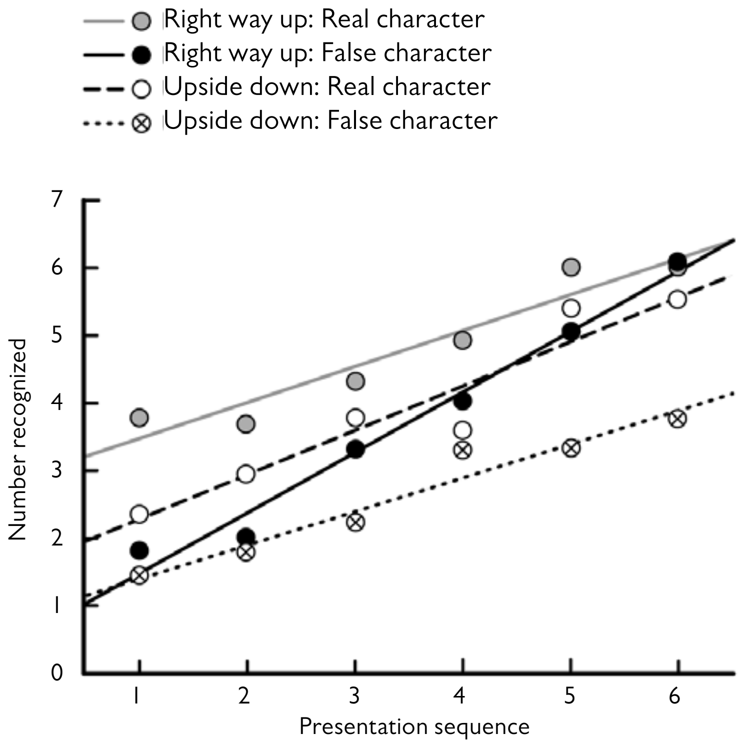

Figure A.7. The results of Suitbert Ertel's experiment on the recognition of hiragana characters. The vertical axis shows the number of words recognized in six successive trials. The four sets of data points refer to real and false characters, right way up and upside down. (Reproduced by courtesy of Suitbert Ertel)

precisely because they had a "right-way-up" feel to them, because of a generic resemblance to real characters. This "intrinsic factor" may not be an alternative to morphic resonance, but rather may depend on their generic resemblance to right-way-up hiragana characters, which was built in from the start.

In retrospect, Ertel thought that he and his students had made a mistake in their initial tests when they were trying to find out whether the fake hiragana characters were indeed similar to real ones: "It gradually dawned on us that we had not instructed the participants of the preliminary tests optimally. We should have asked them to look at the 40 symbols on the piece of paper and mark those that seemed *simpler,* *more pleasant, and less strange* to them. These were the intrinsic features that another test had already revealed to be relevant. Instead we had informed the participants that there were 20 genuine and 20 artificial Japanese symbols and asked them to mark the 20 genuine."

The complexity of Ertel's interpretations illustrates how difficult it is to obtain clear-cut results in old-field experiments. Robert Schorn, Gottfried Tappeiner, and Janette Walde recently carried out an old-field test at the University of Innsbruck. They used stimuli consisting of political, religious, and economic symbols such as flags, emblems, and trademarks that were once well known but have now fallen into oblivion, or ones that are familiar to many people in foreign countries, such as the Chinese Coca-Cola symbol, Indian trademarks, and Far Eastern religious symbols. For each of the symbols, a designer created a corresponding control symbol with a similar general pattern and similar complexity.

In order to find out whether the new symbols were indeed comparable, the experimenters conducted seven pretests with more than two hundred participants, who were asked to indicate which of the symbols in each pair they found less credible or real. In their main experiment, they employed false symbols that were as credible as the originals, if not more credible. Participants were shown pairs of symbols, one real and one false, in a randomly determined order, and they were asked to judge which of each pair had more "spirit." They selected the real symbols significantly more often than the fake ones.[37]

In a second test, the Innsbruck team compared real Russian words written in Cyrillic script with meaningless anagrams of these words. Again the real and false stimuli were presented in pairs, and the participants were asked to judge which had more "spirit." The real words were selected significantly more than the anagrams.

Some of these tests took place through the Internet, illustrating the potential for widespread public participation in automated morphic resonance tests. Kimberly Robbins and Chris Roe, at the University of Northampton, England, carried out the most recent old-field experiment using genuine and false Chinese characters. The experimental design was similar to Ertel's. Participants were first shown a PowerPoint presentation consisting of five real and five false Chinese characters in a random sequence, seeing each character for three seconds. They were not told that some characters were real and others false. They were then given a sheet with twenty characters on it and asked to circle the ten they had just seen. The other ten characters were "decoys," and again five were real and five false. The participants recognized the real characters significantly better than the false ones. With the decoys, participants had significantly more false memories of real than false characters, consistent with a morphic resonance effect.[38]

Nevertheless, all old-field tests face the difficulty of controlling for "intrinsic factors" that might make old symbols, words, or rhymes more memorable or more attractive than newly invented ones. But are intrinsic factors and morphic resonance genuine alternatives? Intrinsic factors may themselves depend on morphic resonance.

A.9 Improving human performance

The simplest new-field tests start with two new patterns. The first step is to find out how easily they can be learned or recognized. The second step is to build up morphic resonance from one and not the other. If morphic resonance is playing a part, the one that has been "boosted" should subsequently be easier to learn or recognize; there should be no such change with the control.

The first new-field test was carried out with hidden images, following a suggestion by Nicholas Humphrey. Such pictures seem to make no sense at first, or contain only vague hints of patterns (see figure A.8a). Seeing the underlying image (figure A.8b) involves a sudden Gestalt shift; the picture takes on a definite meaning. After this has happened, it is difficult not to recognize the hidden image and hard to believe that others cannot see it. If morphic resonance is at work, a hidden image should become easier to recognize if many people have already seen it.

Figure A.8a. A hidden image, as used in a television test for morphic resonance. The image is revealed in figure A.8b.

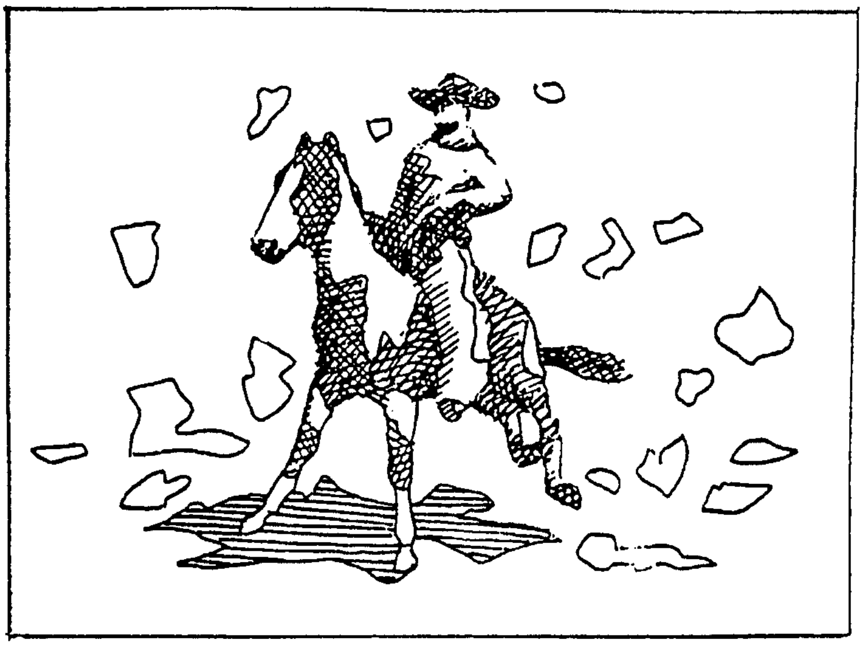

Figure A.8b. The image hidden in figure A.8a.

In the summer of 1983, a British television company, Thames Television, made it possible for me to conduct an experiment of this kind. The two puzzle pictures were specially produced by an artist and designed to be difficult, so that only a small minority of people could spot the hidden images. Before the television broadcast in Britain, I sent both these pictures to collaborators in Europe, Africa, and the Americas. Each experimenter showed both pictures for one minute each to a group of participants before the transmission, and afterward to another group of comparable participants. The number of people who recognized the hidden image was recorded.

The experimenters did not know which of the pictures was going to be shown on television, and nor did I. On the TV show itself, one was picked at random and shown to about two million viewers. After several seconds the answer was revealed, and this then "melted" back into the puzzle picture so that the previously hidden image was now readily apparent. The same picture was shown once more at the end of the program.

The percentage of participants recognizing the control picture before and after the TV broadcast did not change, while the percentage recognizing the image shown on TV in Britain increased. This effect was statistically significant, with a probability of less than one in a hundred that the result arose by chance.[39]

The experiment was repeated, using different images, on BBC television in November 1984 on a popular science program called *Tomorrow's World*. Again there were two puzzle pictures with hidden images. Experimenters all over the world tested groups of participants to find out what proportion could recognize the hidden images within thirty seconds. Such tests were carried out in a five-day period before the TV transmission in Britain, and with comparable participants in a five-day period afterward. On the TV show, one of the two images was selected at random and shown to eight million viewers, to whom the answer was revealed.

This picture did in fact become significantly easier to recognize elsewhere while there was no change with the control. But this positive effect was confined to participants in continental Europe; there was no effect in North America. The disparity was surprising. Morphic resonance should not be distance-dependent. One possible explanation was that in Europe, where the time difference from Britain is only one hour, people were more "in phase" with the British TV audience than people in America, with a five- to eight-hour time difference.

A new hidden-image experiment was carried out in February 1985, with a TV transmission in Germany by Norddeutscher Rundfunk. Again there were two pictures, of which only one was shown on television. This experiment was coordinated by Susan Fassberg, in Freiburg im Breisgau. She arranged for thousands of participants to be tested in various parts of the world, predominantly in Britain. As in the previous experiments, there was no significant change in the proportion of people recognizing the control picture, but the proportion recognizing the test picture *declined* in Britain and elsewhere after being seen by about half a million people in North Germany! The decline was significant, at the 2 percent level of probability. From the point of view of morphic resonance, there should have been an increase. From a Skeptical point of view, there should have been no change. Nobody predicted a decrease.

This result showed that other factors were coming into play, but what were they? No one knew. This puzzling finding discouraged anyone from doing more tests on television, which were complicated to arrange.

In 1987, the Institute of Noetic Sciences (IONS), near San Francisco, announced an award for the best student research on morphic resonance. An independent panel of judges assessed the entries, and the results were announced in 1991.[40]

The winner of the undergraduate award was Monica England, a psychology student at the University of Nottingham, England. Her test was stimulated by anecdotal evidence that some people find it easier to do newspaper crosswords the day after they have been published than when they first appear, an effect that could be due to morphic resonance from thousands of people who have already done the puzzle.

The experiment involved two puzzles from a London newspaper, the *Evening Standard,* which was not distributed in Nottingham. The newspaper kindly cooperated by supplying two unpublished puzzles a week before they appeared: the "easy crossword" and the "quick crossword." The easy crossword had simple cryptic clues and the quick crossword had single-word clues that required synonyms as answers.

Monica England tested about fifty students the day before the crossword puzzles were published in London, and a further fifty the day after. Both groups of participants were also given two control puzzles, which had been published in the *Evening Standard* two weeks earlier. The participants were given ten minutes with each crossword to solve as many clues as possible.

On average, participants solved significantly more clues with the easy puzzle after it had been published than before. There was no change with the control crossword. By contrast, with the quick crossword there was no significant difference in the test crossword relative to the control.

I repeated this experiment in 1990, again using easy and quick crosswords from the *Evening Standard,* and testing people with the help of experimenters who lived far from London, where the participants would not have seen this London newspaper. Again, the scores with both crosswords were compared with controls. There was a slight improvement in scores with the easy crossword after it was published, but this change was not statistically significant. By contrast, there was a statistically significant increase with the quick crossword. Thus the results were inconsistent, giving a positive effect with one crossword but not the other, as in Monica England's experiment. In her test the easy crossword showed a positive effect, and in mine the quick crossword.

While reflecting on these results, I realized that I taken it for granted that all the crossword puzzles were new, and I had assumed that they would be unaffected by morphic resonance from crosswords in the past. I then inquired how the crosswords were put together, and found that the compilers frequently recycled clues from previous crosswords. Hence these simple crosswords did not provide a good test for morphic resonance, since many of the clues were in fact not new.

Zoltan Dienes, then in the psychology department at the University of Oxford, won the IONS award for graduate students. His participants were required to decide quickly whether a string of letters they saw on a computer screen was a meaningful English word or a nonword. This experiment involved a phenomenon known to psychologists as "repetition priming," which occurs when a word (or other stimulus) is recognized more quickly after repeated exposure to it. Dienes reasoned that later participants might find it easier to recognize stimuli if others had done so earlier.

The participants saw strings of letters flashed on a computer screen and had to indicate whether a string was a real word or a nonword by pressing computer keys as fast as possible. Dienes used two sets of words and non-words. One "shared" word set was presented to all ninety participants, while the second "unique" set was shown only to every tenth participant. The experiment thus involved eighty "boosters" who viewed only the shared stimuli and ten "resonators" who saw the shared stimuli together with the unique ones. If morphic resonance were at work, the speed at which the shared stimuli were correctly judged should increase relative to the speed at which unique stimuli were correctly judged. In order to maximize the resonance between participants, all experimental trials were conducted in a controlled environment with distinctive visual, olfactory, and auditory cues.

The outcome was positive and statistically significant. The more often a nonword had been seen before, the faster subsequent resonators responded to it. However, when Dienes tried to repeat this experiment at the University of Sussex, there was no significant effect.[41]

Professor Suitbert Ertel carried out two new-field experiments in addition to the old-field tests discussed above. The first took place through a magazine called *Übermorgen*. The experiment was based on anagrams, such as "*Seterleirei*" for "*Reiseleiter,*" and the task for the magazine's readers was to find the normal words. Readers were asked to repeat each anagram and its corresponding word as often as possible. When they had memorized them, they sent a postcard to the experimenters on which they gave their telephone numbers. Their names were entered for a raffle, and thirty of them received free copies of one of my books. They had to face a possible checkup by telephone to see whether they knew the words, and a random sample of fifty people was actually called, with satisfying results. About a thousand readers participated.

These readers did not know the experiment also included sixty students at Dresden University, where the magazine was not distributed. These students were tested with the same ten anagrams and with ten additional anagrams that had not been boosted by readers of *Übermorgen*. Could the students solve the boosted anagrams better than the controls? On average they could, but the effect was not statistically significant.[42]

Ertel's second experiment took place through another magazine, *PM*. This was designed to be fun for readers, and used artificial German words in standard phrases or proverbs. The meaning of the artificial words had to be guessed from their context, like "*Die blampe Leier*," "*Das ist doch ein blamper Hut*," in which "*blampe*" was invented to replace "*alt*." Ten new words had to be learned in this way, in a total of one hundred phrases. The count of new meanings (e.g., the meaning *alt* = *blampe* occurred eight times) resulted in a ten-digit telephone number that the readers called. If the number was correct, they received a confirmation from an answering machine. Sending a postcard with the correct number enabled the participants to take part in a raffle for fifty copies of my book. Altogether 1,017 readers of *PM* magazine participated.

Again, the influence of this boosting was tested in Dresden, where participants had to push a button saying "artificial" or "real" as quickly as possible after a word had appeared on a computer screen. The boosted artificial words were mixed with twenty other artificial words that had not been boosted. The students in Dresden were tested before and after the *PM* boosting. There was no difference in their success with the boosted and the control words.

One problem with this test was that the conditions in which the participants saw the words were very different from the context in which the *PM* readers learned them. One group of people were doing puzzles in a magazine at home or in other informal settings. The others were being tested for their reaction speed on computers in a laboratory. These dissimilarities could have weakened any resonance effect.

In summary, small-scale new-field tests have not given consistent, repeatable results. But perhaps they are not sensitive enough; the resonance may be too weak to be detectable with only a few hundred or a few thousand boosters.

Morphic resonance can be investigated on a much larger scale by studying changes in human performance over time. Does the performance of new skills show a tendency to improve as time goes on? Do video games get easier to play? Do new sports such as skateboarding and windsurfing become easier to learn? Anecdotal evidence suggests that they do, but such changes are not documented quantitatively, and the situation is complicated by other factors, like improvements in equipment, fashion, better teaching methods, and so on.

One of the few areas in which detailed data are available over many years is for the scores of IQ (Intelligence Quotient) tests. Around 1980, I realized that if morphic resonance occurs, average performance in IQ tests should be rising, not because people are becoming more intelligent, but because IQ tests should be getting easier to do as a result of morphic resonance from the millions who have done them before. I searched for data that would enable this prediction to be tested, but could not find any published figures. I was therefore intrigued in 1982 by the finding that average IQ test scores in Japan had been increasing by 3 percent a decade since the Second World War.[43] Soon afterward, it turned out (to the relief of many Americans) that IQs had been rising at a similar rate in the United States.

The psychologist James Flynn first detected this effect in America in his study of intelligence tests by U.S. military authorities. He found that recruits who were merely average when compared with their contemporaries were above average when compared with recruits in a previous generation who had taken exactly the same test (figure A.9). No one had noticed this trend because testers routinely compared an individual's score with others of the same age, tested at the same time; at any given time, the average IQ score is set to one hundred by definition.[44]

Comparable increases are now known to have occurred in twenty other countries, including Australia, Britain, France, Germany, and Holland.[45] Many attempts have been made to explain this "Flynn effect," but none has succeeded.[46] For example, very little of this effect can be ascribed to practice at taking such tests. If anything, such tests have become less common in recent years. Improvements in education cannot explain it either. Nor, as some have suggested, can increasing exposure to television. IQ scores began rising decades before the advent of television in the 1950s, and as Flynn has commented wryly, television was usually considered "a dumbing down influence until this effect came along."[47] The more research there has been, the more mysterious

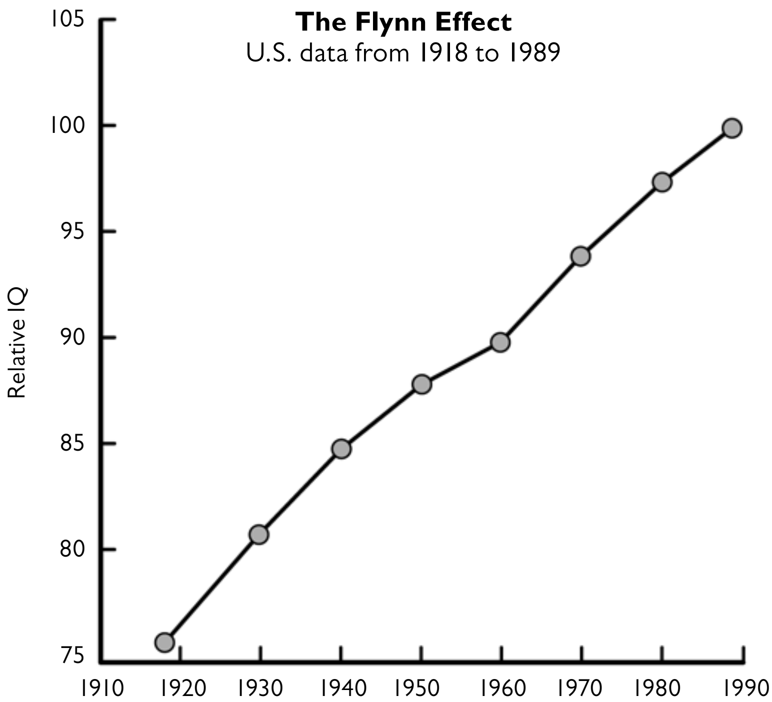

Figure A.9. Changes in average IQ test scores in the United States from 1918 to 1989, relative to 1989 values. (Data from Horgan, 1995) the Flynn effect has become. Flynn himself describes it as "baffling."[48] But morphic resonance could provide a natural explanation.

If the Flynn effect is indeed explicable in terms of morphic resonance, it shows that such resonance effects are relatively small. If millions of people taking IQ tests lead to increased scores of only a few percentage points, then in experiments involving a few hundred people, or at most a few thousand, the morphic resonance effects may be too small to detect against the "random noise" due to wide variations in performance from participant to participant.

Morphic resonance might also have a bearing on "grade inflation," the phenomenon of increasing academic grades over time. An evaluation of the grading practices in American colleges and universities shows that since the 1960s, grades in the United States have risen at a rate of 0.15 per decade in a 4.0 scale. In Britain, the proportion of students achieving A grades in school examinations and first-class university degrees has also been increasing steadily. This phenomenon has caused an intense debate: some people lament that standards are becoming more lax, while others assert that students are producing better work. But morphic resonance would again provide a simple explanation. Standard examinations are becoming easier to do because so many people have already done them.

When my elder son, Merlin Sheldrake, was about to take the British GCSE (General Certificate of Secondary Education) examinations at age sixteen, he and a group of his school friends came up with an ingenious plan for increasing their scores with no extra effort. In each exam, they would do the last questions first, and then return to the beginning and follow the normal sequence. Hence they would be about ten minutes behind everyone else in Britain sitting the same exam at the same time, and should therefore receive a boost by morphic resonance. They actually put this idea into practice, reasoning that if morphic resonance existed, they might score better, and if it did not, they had nothing to lose.

This idea raises the possibility of an experiment within the frame-work of large-scale examinations. The order of questions carried out by a random sample of students could be changed. Are scores significantly higher on questions that other students have answered earlier?

New-field tests for morphic resonance could also be done on a large scale using newly released puzzles, such as Sudokus and computer games. Such tests would require the cooperation of the game or puzzle companies. As in the hidden-image and crossword experiments, there would need to be a control puzzle or game that was not released during the period of the test. Groups of participants would need to be tested in places where they do not have access to the newly released puzzles or games, and such tests would be done before and after the puzzles or games were released elsewhere.

A.10 Resonant computers

The hypothesis of formative causation applies to self-organizing systems such as crystals, cells, and animal societies. Morphic fields work by imposing patterns on otherwise indeterminate events. Hence morphic resonance does not apply to machines. Machines are not self-organizing systems, but are made of components put together in factories according to human designs. Their functioning is strictly determinate—they are designed to be predictable, and to do the same things over and over again. Even when computers incorporate "randomness" in their programming, the random numbers are generally provided by pseudorandom algorithms, rather than by sources of genuine random "noise."

Francisco Varela, a neuroscientist, tried to test for morphic resonance in a computer in the 1980s. He programmed it to carry out the same sequence of operations with 100 million repetitions, and measured how long these repetitions took.

There was no speeding up. Varela published this result in the *Skeptical Inquirer,* claiming that it falsified the hypothesis of formative causation.[49] He argued that the changes imposed on silicon chips by the workings of the computer were equivalent to repeated crystallizations, and hence they should happen faster if the hypothesis of morphic resonance was correct.

I replied that there was a difference in kind between the spontaneous formation of a crystal and the changes imposed on a silicon chip in a computer. But most important, the experiment was technically misconceived. Computers work by a rapid series of operations pulsed by the computer's internal clock. In Varela's computer, the clock paced the instructions in the program with a unit time of one microsecond. Even if the silicon chips had responded faster to the pulsed instructions as a result of morphic resonance, the sequence of operations was fixed by the clock and could not have speeded up.[50] Many readers of the *Skeptical Inquirer* independently pointed out this fatal flaw in the test.[51]

One morning in the spring of 1990, I was suddenly deluged with telephone calls from science journalists and computing science departments at universities. The cause of the excitement was an article in a British magazine, *Computer Shopper,* describing some remarkable results about which I knew nothing. The report stated that an Italian computer scientist, Dr. Lora Pfilo, had recently been carrying out an experiment with genetic algorithms, trying to find the best solution to an engineering problem by letting prospective solutions play against each other over successive "generations." The simulation was running on the Bologna University connection machine, a massive parallel computer with 256,000 processors. The article stated that Dr. Pfilo noticed that the first time the program ran it took forty minutes to complete, yet the second time she ran it, it took twenty-three.

She found the sudden decrease in processing time a little worrying—perhaps it had not run correctly owing to a power surge. So she ran the program again, and although the results matched up with results from the second run, the processor time had decreased to thirteen minutes. She ran the program repeatedly, and eventually the time decreased to one minute and twelve seconds. The result amazed her. What was this extra causal factor that led to the decrease in programming time? In January she contacted a colleague visiting Milan University—Professor

Kvitlen Duren, a professor of mathematics from the Institut Svit Chotiri in Kiev.

The article continued with an interview with Professor Duren, who was in London to address the Royal Society. He too claimed to have noticed a decrease in processing time in one of his computers, but not in another that was running the same genetic algorithm program. He found that the computer that ran more quickly had some additional circuitry, including a hardware random number device based on a reversed Zener diode that generated quantum randomness. The other computer worked on a standard pseudorandom number algorithm. Professor Duren was reported as saying:

> We had great difficulty accepting this at first but what must have been happening was that, in some sense, information from previous runs was being "stored" out there. At this point, my good friend Lora Pfilo contacted me and in the course of a general conversation we discovered we had both observed the same effect. What I had been calling causal acceleration, she called morphic resonance . . . What happens on the connection machine is that there is a quantum indeterminacy in the scheduling of the multiple processes. The indeterminacy is sufficient to produce the effects that Lora saw.

I rang up *Computer Shopper* magazine and asked to be put in touch with the author of the article. Soon afterward, he rang me back and said, "Before we go any further, please look at the date on this issue of *Computer Shopper*." I did. It was April 1.

The author, Adrian Owen, and his colleague John Kozak invited me to meet them in a local pub soon afterward. Professor Duren, pictured in the article, was none other than John Kozak with a false beard. Lora Pfilo was an anagram of April fool. They told me that they were both intrigued by morphic resonance and had been thinking about ways in which it might apply to computers. They had also tried to think of an April fool article that would be sufficiently plausible to stimulate widespread interest, without being recognized immediately as a spoof. They succeeded beyond their wildest expectations.

In 1993, Steven Rooke, of Tucson, Arizona, an experienced computer programmer, explored the possibility of carrying out in reality what the report in *Computer Shopper* had described. He used a computer graphics system, a reversed Zener diode as a source of quantum noise, and a genetic algorithm program that converged on a target image. The question was whether, in a randomized series of runs, the rate of convergence on this target would increase. Rooke had to overcome a variety of technical problems, and the results of the morphic resonance tests were inconclusive. But his programs generated extraordinarily beautiful graphic images, which he then produced commercially.

Looking back on his experience, in October 2007, he doubted whether the quantum event generator and the computer programs were tightly coupled enough to constitute a morphic field.

> Even if a genetic program convergence process can resonate with processes occurring fleetingly in time previously, it seems likely that there will need to be a much tighter coupling between the thing generating the source of randomness (the quantum event generator) and the novel thing being produced. Designing such experiments is fraught with difficulties, including keeping track of previous solutions, so as to know whether a new solution is really new; all preparatory work should be done solely with pseudo-random numbers.[52]

In morphic fields, all the different parts of the system are linked together and the fields work by affecting random processes. The problem Rooke highlighted is that the random numbers were fed into the computer, but the random number generator was not linked to the system in any other way. To make it more closely coupled, the random number generator would have to be affected by the processes it was itself affecting. One way to make a more closely coupled system, suggested by the mathematician Ralph Abraham, would be to use optical feedback—the simplest model being to point a video camera at a screen that displays the output from the camera at low definition, leaving scope for random noise.

But there may be a surprising new possibility. We are used to the idea that all computers are digital; but in the early days of computing, in the 1950s, analog computers were serious contenders for the path of the future. They enabled complex, self-organizing patterns of activity to develop through sometimes chaotic, oscillating circuits in electronic devices. William Ross Ashby, a British pioneer of cybernetics, published in 1952 an influential book called *Design for a Brain,* which showed how analog cybernetic circuits could model brain activity, including leaps from one state or level to another. Then digital computers took over, and analog systems were forgotten.

In a recent revival, the analog approach has led to astonishing results in the creation of "living machines" in the form of insectlike analog robots. These machines achieve feats of self-organization, and even of learning and memory, whose complexity belies the fact that these machines contain less than ten transistors and have no computers within them at all. Mark Tilden, the inventor of these machines, built electronic systems that rely on inputs from sensors as the robots move. The activity of the wavelike, rhythmic circuits is partly chaotic and unpredictable, and is influenced by what has gone before. As Tilden put it, "When conditions are repeated exactly the same way twice, a digital computer will respond in exactly the same way. These analog devices may or may not do the same thing twice! You can influence them, but you don't actually have any power over them."[53] Tilden's work has inspired a new kind of "reaction-based" machine building, called BEAM robotics (Biology Electronics Aesthetics Mechanics, or Biotechnology Ethology Analogy Morphology).

Can morphic fields be established in electronic machines? No one knows. But for research on this question, a good starting point might be self-organizing, wave-based analog robots that include truly random elements.

If morphic fields were to come into being within such probabilistic analog systems, they would automatically have an inherent memory, without the need for special memory-storage devices like hard drives and memory chips. They would also enter into morphic resonance with similar computers around the world, without the need for communication through wires, cables, or radio signals. They would share a collective memory. An entirely new technology would be born.