APPENDIX I

# THE VICIOUS CIRCLE PRINCIPLE OF HUMAN DEVELOPMENT

In this appendix I shall briefly present a theory of human development.[1] This theory is based on what I call *the vicious circle principle*, which itself presupposes Darwin's principle of evolution, as well as the other principles presupposed by that principle, such as the entropy principle and the principle of the conservation of matter.

As regards humankind, where Darwin's theory of natural selection, based on the principle of evolution, is to explain how we humans came to be, the present theory is intended to explain *how we developed afterwards*. This explanation, in keeping with the treatment of explanation in this volume, will consist in indicating in one coherent conceptual scheme the causal relations that are to be responsible for the main thrust of human development to date. Thus where according to the principle of evolution the key cause of biological evolution is *species'* tendency to *mutate*, on the vicious circle principle the key cause of human development is *humans'* tendency to *innovate*. Further, in keeping with the fact that the vicious circle principle presupposes the principle of evolution, the present theory may be seen as an extension of Darwin's theory in such a way as to explain the particular development of humankind.

Where the principle of evolution is the core principle of biology and is presupposed by all the life sciences, the vicious circle principle is here being advanced as the core principle of *human ecology*, to be presupposed by all the *social* sciences, and thereby to constitute the background against which social structure and change are to be understood.

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[1] A much more detailed presentation will be found in my book, *Too Smart for Our Own Good*, presently in preparation; one of the first presentations of the vicious circle principle was in my (1994).

## 1. THE VICIOUS CIRCLE PRINCIPLE

The vicious circle principle (VCP) is both easy to understand and in keeping not only with modern science, but also with common sense. Briefly put, it says that in the case of humans *the experience of need, resulting e.g. from changed environmental conditions, sometimes leads to technological innovation, which becomes widely employed, allowing more to be taken from the environment, thereby promoting population growth, which leads back to a situation of need*. Or, seeing as it is a matter of a *circle*, it could for example be expressed as: *increasing population size leads to technological innovation, which allows more to be taken from the environment, thereby promoting further population growth*; or as: *technological innovation allows more to be taken from the environment, the increase promoting population growth, which in turn creates a demand for further technological innovation*.

Here is the principle in greater detail:

A situation of *scarcity* leads to the experience of *need*
which creates a demand for *new technology*
which in certain cases is *developed* and then *widely employed*
which allows the exploitation of previously *inaccessible resources* – renewable, non-renewable or both
the taking of resources, including sources of energy, *reducing the quantity* remaining
and leading to an *increase in polluting waste*
and the *extinctions* of various species of plants and animals
while at the same time allowing an *increase in resource consumption*
and typically the production of a *surplus* of goods
which are normally or often of *lower quality* than those they are replacing
while the availability of the surplus weakens *internal population checks*
allowing *population growth*
and underlying *migration*, first to areas where the new technology is being used to produce the surplus, resulting in *centralisation* and *urbanisation*, then, when possible, to areas where it is *not*, taking it along

the new technology invariably requiring *specialisation* for its use
which gives rise to an *increase* in the *complexity of society* as a whole
thereby promoting *social stratification*
in which there is an increase in the *property* and thereby *power* of the upper strata
while the lower strata experience an *increase in work*, and a *worsening* of their *quality of life*
while the surplus in the hands of the upper strata leads to conflict in the form of *war* amongst themselves
at the same time as it allows their consumption of *luxury goods*, many of which can be produced thanks to technological development
as well as providing them with *leisure*
some of which is devoted to *cultural development*: the arts, architecture, philosophy, science
while the presence of the surplus also leads to *increased trade*, i.e. *economic growth*, amongst the upper strata
which (together with other things) has the effect of *reducing* the *self-sufficiency* and thereby the *security* of society as a whole
while the population grows so as to *overshoot* the surplus, i.e. to *over-exploit its resources* such that the surplus begins to dwindle
the excess population combined with the reduction in available resources leading to *economic decline*
eventuating once again in *scarcity* and *need* (and possible *population reduction*).

So there you have the vicious circle principle in greater detail. But the above still constitutes only a sketch, the central points of which I shall now fill out. (Note that the present section constitutes primarily a *presentation* of the VCP; the bulk of its support comes in the next section.)

### *Scarcity and Need*

All animal species need oxygen, water, food, breeding sites, etc. Let us call these their *basic* needs. In the case of humans in particular there also exist what may be termed *perceived* needs, such as a businessman's perceived need to make as large a profit as possible, or a woman's perceived need for a new kind of cosmetic.

When a basic or perceived need is difficult or impossible to meet, it constitutes an *experienced* need. Thus experienced needs may or may not threaten the lives of individuals or their ability to procreate, i.e. be basic needs. In all cases, however, experienced needs result from a *scarcity* of whatever it is that is needed. So, for example, it may be the case that vegetable foods have become relatively scarce, such that the human population has an experienced need for more food – an experienced need which is also a basic need.

In the case of other species, such an experienced basic need is typically brought on by changes the populations of the species have not themselves influenced, such as climatic changes leading to a decrease in rainfall. This can also happen in the case of humans. But what is typical for humans is that such changes are brought about by humans themselves, through the operation of the VCP.

As regards other species in a similar situation, basic experienced need, if prolonged, would lead to a reduction in the size of the population, or to the species' extinction and/or mutation to another life-form in which the need is not experienced or is less severely felt. In the case of humans, on the other hand – and this is a key aspect of the VCP – the experienced need may be overcome via *technological innovation*.

### *Innovation*

As suggested by a number of authors, including Thomas Malthus, Ester Boserup and Richard G. Wilkinson, in situations of scarcity, necessity can become the mother of invention. This does not mean that every instance of experienced need will lead to invention – all that is required for the vicious circle to operate is that *every now and then* a technological solution be found. Though the discovery of such solutions may be rare, once a useful innovation is hit upon it is remembered, and its use spreads to other cultures, being easily transmitted largely thanks to the objective nature of technology. Knowledge of how to employ a particular innovation thus spreads to all areas of the world where it can be of use, i.e. where its employment relieves experienced need, and its introduction is followed by migration to those places.

### *Resource Depletion*

The use to which the new technology is put typically involves increasing the amount taken from the environment by making available resources that were previously *inaccessible*. This can mean either allowing direct access to the resource in question, as in the case of mining, or transforming conditions so that what was previously not a usable resource becomes one, such as in the case of land-use changes or petroleum refining. Often it will involve the partial substitution of one resource for another in such a way that what is produced from the two resources together is greater than what was obtained from the original alone. Garden produce may be consumed along with naturally growing plants; synthetic materials made from oil may be supplemented to and partially substitute for those made of cotton, wool and leather. Though efforts to extract the original resource may in principle be reduced when the technology permitting the extraction of the substitute is in place and functioning, this seldom happens in practice; whether it does or not, and whether or not either of the resources is renewable, the result has consistently been a decrease in the total resources remaining.

Thus when new technology is employed to extract more from the environment, the result is a *reduction* in the quantity of remaining resources, and a *permanent* such reduction if the resource in question is non-renewable. Here it is important to distinguish resources from reserves and stocks. *Resources* are a part of nature that, given present and future technological development, could be of immediate use to humans. *Reserves* are those resources which are available given present technology. And *stocks* are those reserves already taken from nature and set aside for future use.

Though we can be sure that the quantity of non-renewable resources is constantly diminishing, we cannot be sure exactly what our future reserves will be, since we do not know whether technological innovations in the future may increase accessible resources (reserves) or reveal resources which we today do not see as such. So, for example, uranium, always a resource, was not appreciated as such – not turned into a reserve – until the advent of nuclear technology.

Thus, with the implementation of a new technology, both reserves and stocks may be increased, and it is the quantity of these, not resources, that directly affects the economic value of such substances. So the implementation of a new oil-drilling technology, for example, may increase oil reserves and lower the price of oil, while at the same time the quantity of oil as a resource is constantly diminishing.

Here the distinction between renewable and non-renewable resources is important. What has made the vicious circle particularly vicious is its undifferentiated involvement of both kinds of resource, and the human dependence on non-renewable resources that has resulted. On the other hand, no resources are renewable if they are overexploited. While populations of large mammals can constitute a renewable food resource for humans, if the species they represent is driven to extinction – as many were during the Upper Palaeolithic – they are not only non-renewable but become non-existent.

To this it may be added that in general humans' increasing extraction of resources (and the resultant increase in waste their use gives rise to) leads to increasing numbers of extinctions of other species – both plants and animals. Thus not only may such species be eradicated directly, e.g. by over-hunting, but also indirectly through the diminution or spoiling of their resource base.

If all potentially renewable resources were renewed or allowed to renew themselves, as is normal in the case of other species, and if at the same time we had not become dependent on the use of non-renewables, then it would have been possible to avoid getting caught up in the vicious circle, as many modern hunter-gatherer communities apparently had not before the intrusion of other cultures. But dependence on non-renewable resources leads to a situation in which technological innovation becomes a must in order to extract a replacement when the resource in question has been exhausted, just as it becomes a must that there exist such a replacement to turn to.

### *Waste and Pollution*

If the energy used to extract the newly available resources is biotically based, and if those resources themselves are biotic, waste will be decomposable. But if non-renewable fuel sources are used to produce non-biodegradable products, pollution and accumulating garbage will result. Though some non-biodegradable products may be recyclable, the second law of thermodynamics makes perfect recycling impossible, so all such products eventually become waste.

### *Surplus*

In the case of e.g. a scarcity of vegetable food, at one particular stage of human development technological innovation consisted in the development of the lance, which allowed an increase in the consumption of meat as a replacement for vegetable matter. At another time it took the form of irrigation, allowing the growing of crops in areas that would otherwise have been too arid. Once the use of the new technology becomes widespread, the result has often meant a shift from a scarcity to a *surplus*.

Note that the surplus, though meeting the same need, may be of a resource different from that which was scarce, and that it can be quite great. What is typically the case, and is very clear in the development of the lance, is that the resource that was scarce (vegetable food) is at least partly *replaced* by another resource (meat) that meets the same experienced need (more food). Other examples of this phenomenon include the replacement of meat with vegetable products thanks to the technological innovations of the horticultural and agrarian revolutions, the replacement of wood with coal at the time of the industrial revolution, and the replacement of whale oil with petroleum, beginning in the middle of the nineteenth century.

In the case of the development of the lance, the new food source, meat, was superior (higher in protein content) to what it was replacing. However this is not always the case, and, as has been implied by Wilkinson, more often has *not* been the case, such as when meat was largely replaced with vegetable products at the time of the horticultural revolution. Though the use of the digging stick – and later the hoe – in planting tubers allowed the harvesting of much *more* food than was available before, the food was of a lower quality.

What may be noted here, particularly against the background of the idea that necessity is the mother of invention, is that, as argued by Wilkinson, after an innovation has been made, necessity has more been the mother of the *employment* of invention. Here the VCP, in saying that invention is paradigmatically incumbent upon experienced need, supports Wilkinson's view that technological change is typically *implemented* in a situation of need, as against the view that such change is the result of the seeking after a better life.

### *Social Stratification*

Social stratification, or a 'pecking order,' is a manifestation of Darwinian intraspecies survival of the fittest, and exists in the populations of virtually all medium- to large-size animals. In the case of humans, technological development has made possible a pecking order that has now become global, where few have much power and many have little or none. The invention of *language* (which itself may be seen as a tool) is important here, for it is through language that orders can be given and passed on to those not present. *Weapons* are also important, in that military strength is the bottom line when it comes to power.

Pushed by the VCP, the destructive capability of weapons has constantly increased throughout our development, and channels of communication have constantly grown. This has had the effect of steadily increasing the power of the strong and lessening that of the weak, at the same time as it increases the complexity and reduces the security of society as a whole.

This development, involving weapon and communication improvement, globalisation, centralisation, and population growth, is a manifestation of the VCP, the operation of which works counter to the survival of the human species, involving as it does constantly increasing consumption, population size and quantities of waste, all of which tend to move the species out of equilibrium with its surroundings, thereby increasing the likelihood of its becoming extinct.

### *Quality of Life*

With social stratification come of course inequities. While the quantity of resources going to the weak is normally only sufficient to allow them to raise children, that which remains – i.e. virtually the whole of the surplus – goes to the powerful. Thus, given sufficient surplus, there will develop among other things the production of *luxury* goods over and above the goods necessary for the survival of the population. Such goods may themselves be of a technical nature, as are e.g. stereos and pleasure boats, and thereby constitute instances of non-typical technological change, i.e. technological change that does not support the maintenance or growth of the population, but merely fills non-basic perceived needs.

Leisure, or the potential for leisure, will also increase for the powerful. The efforts required to produce usable products from natural resources will be those of the weak, the greater the disparity between the powerful and the weak, the less the leisure for the latter.

Thus, so long as there exists sufficient surplus, it is to the advantage of the powerful that the weak bear many offspring, to do their work for them and to fight in their armies. Population growth amongst the weak widens the gulf between them and the powerful through reducing the value of an individual's labour; and it increases the military strength of the powerful vis-à-vis others in power by providing them with more soldiers – the existence of both factors perhaps explaining why those in power have constantly turned their backs on problems of overpopulation.

The fact that a particular resource can only be significantly exploited thanks to the introduction of new technology implies that the acquisition of that resource should require more work than did that of the original resource before it became scarce. Thus, following Boserup and others, we see that the employment of horticultural technology in the Neolithic era, involving e.g. the construction and use of stone gardening implements, requires more work per unit food acquired than did the earlier hunter-gatherer technology. This line of reasoning takes a slightly different form when applied in a modern context, for much of the extra work required in modern agriculture and other production is done by machines, which obtain their energy from fossil fuels. So we should then say more generally that the use of new technology tends to require the expenditure of more *energy* than did the technology it is replacing. Still, with the first introduction of a new technology, before the supporting non-human infrastructure has been built up, an increase in the amount of work performed by the weak has been the rule even in the industrial era.

That the weak have less leisure and do more work means a lowering in the quality of their lives, particularly for those drawn into the extraction of resources or the production of the goods or services resulting from the implementation of the new technology. The more onerous lifestyle for the weak that accompanies the transition to using a new technology, and the generally lower quality of their food in particular, raises their mortality. However, as the use of the new technology becomes an integral part of society, this effect will tend to lessen – until the next more effective (exploitative) technology is implemented.

Mortality from infectious diseases is another aspect of the VCP. We have acquired a vast number of our infectious diseases from the animals we domesticated in our technological development of horticulture. In conjunction with this, the constant growth of the human population steadily increases the breeding grounds of the bacteria and viruses responsible for these diseases, thereby constantly increasing the likelihood of major epidemics.

### *Conflict*

On the VCP, the killing of humans by other humans is a population check that expresses itself particularly in situations of overcrowding, and has been made possible or greatly enhanced through the development of weapon technology. In our primitive past, human males, like the males of other species, would fight with each other over breeding territory and/or females, the losers often having to go without a mate. But as it became possible for ever fewer people to accumulate ever-increasing quantities of wealth and military power, this fight over territory has taken the form of *wars* between *states*, i.e. between the *leaders* of states. War, among other things, is a check to the size of the total population manifest in the fighting of powerful individuals over territory.

### *Cultural Development*

The leisure had by the powerful, in combination with the human tendency to innovate, has given rise to the arts and philosophy. And in combination with constantly increasing technological know-how, it has allowed for their development e.g. in the form of monumental architecture and science. Thus, on the VCP, with its strong biological-ecological orientation, the arts and sciences are an 'emergent property' of the basic dynamics of human development – they could be seen as a side-effect. In the case of modern science, however, as expected already by Francis Bacon, some of the results of the search for knowledge and understanding of the physical world have been channelled back into the productive effort (particularly that of the *military*), thereby speeding up our course round the vicious circle.

### *Economic Growth*

As suggested above, the implementation of a new technology will quite generally mean an increase in society's use of *energy*. Historically, the first non-human source of such energy was wood used in fires, and later domesticated animals such as the ox and the horse, and since the industrial revolution mainly fossil fuels. Note that while energy is itself a non-renewable resource (though its *source* may be renewable) which in certain cases can be made available via technological change, unlike metals and certain other resources, it cannot be recycled.

All use of technology demands energy, generally the more sophisticated the technology, the greater the energy required per unit it produces. This extends to trade, such that the energy required to trade a particular entity increases with the distance between the points of trade. Increase in the availability of energy thus promotes economic expansion, thanks both to the increasing number of products technological development makes available, and the ease of transportation it makes possible.

Thus the surplus resulting from the use of the new technology may be, and in modern times virtually always is, put on a market, thereby giving rise to trade, or, in the case of ongoing trade, giving rise to an *increase in trade*, that is, to *economic growth*. If the surplus is sufficiently great, this economic growth will also be manifest in related areas, such as transportation, involving e.g. an increase in the number of transport vehicles and the improvement or building of roads and other transportation systems. In this way self-sufficiency decreases, and there is a further reduction in the security of the population.

### *Population Overshoot*

The paradigmatic increase in available resources incumbent upon technological change is an increase in *food*. At first such an increase may mean more to eat for each person. But what invariably happens in the longer term is that it leads not to people consuming more, but to *more people consuming*. That is, the surplus resultant upon the technological change, given an increased number of breeding sites (housing) also made available by technological development, will lead to *population growth*. This is another key aspect of the VCP, namely, that technological change employed to counteract need often *overshoots the mark*, giving rise to a surplus and a consequent increase in population. Provided with an improvement in our immediate conditions for survival, we, as would the members of other animal species, generally succeed in seeing to it that more of our offspring live to an age where they themselves can reproduce.

As has been emphasised by Virginia Abernethy, throughout human history periods of surplus have as a matter of fact been followed by periods of population growth. Such seemingly minor innovations as the adjustable wrench can have the ultimate effect of providing or increasing a surplus. The increase in the amount of resources that can be extracted from the environment is then taken as permanent, and what Abernethy terms a ‘euphoria effect’ takes hold, leading people to have larger families. Note that the increase in average family size can be extremely small and still result in marked population growth.

Not only does population grow when provided with a surplus, but it grows beyond what the surplus – which is itself dwindling partly due to its being used by a constantly increasing population – can support. Eventually the surplus will be eradicated, thereby closing the vicious circle and taking us back to a situation of *scarcity* and experienced *need*.

## 2. APPLICATION AND CORROBORATION

In order to investigate the viability of our theory of human development based on the VCP, we shall consider the extent to which actual human development to date can be understood in its light. In what is to follow, factual information will first be presented concerning a major period of human development, and then the theory based on the VCP will be applied to that period. Thus the present section is intended both to *provide support* for our theory and, granting its viability, to *explain* the main outlines of human development to date.

### *The Cro-Magnon (Hunting) Revolution – 100,000 BP*

Modern humans originated in Africa some 200,000 years ago, coming first to the Middle East around 100,000 BP, and eventually to Europe about 40,000 BP. At each of these last two times – the first of which was just before the beginning of the last ice age, and the second of which was in the middle of it – there was a marked increase in innovations.

The innovations of 100,000 years ago include the use of bone for tools, the making of tools with built-in handles, and probably the use of skin clothing. The innovations after 40,000 years ago include the systematic hunting of selected animals, the widespread use of blade tools, the ability to create fire, and the invention of lamps, needles (bodkins), spoons, pestles, stone axes, the spearthrower, and, about 23,000 years ago, the bow and arrow.

At each of these times, i.e. 100,000 and 40,000 years ago, there was a spurt in human population growth. More generally, i.e. over the Cro-Magnon era as a whole, what we see is continuous population growth up to the Mesolithic period (12,000 BP).

Perhaps what is most notable with regard to human technological development during the last ice age (80,000 to 10,000 BP) is the improvement in *weapons*, more particularly the development from the wooden lance to the stone-pointed throwing spear, to the throwing spear which could be hurled a greater distance with the aid of a spearthrower, to the spear with a sharpened bone point – later with barbs on it, and on to the bow and arrow, eventually with poison-tipped arrows. It may in fact have been the case that the demise of the Neanderthals about 28,000 years ago was a result of most if not all of this development of weapons occurring with us. To this it may be added that throughout human existence the constant improvement of weapon technology has made itself felt in an absolute increase in the killing of humans by other humans.

By the end of this first period of human development, many species and genera of large mammals over the whole world had become extinct. Africa lost 50 of its large mammalian genera – some 40 per cent – after modern humans came into existence, with the peak and end of extinctions there occurring at around 40,000 BP. Australia lost 21 genera of large mammals (86%) after the arrival of humans, peaking at about the same time; and in North America, during the 2000 years after a wave of humans arrived around 12,000 BP, 31 genera (60%) of the mammalian megafauna became extinct, with a subsequent similar reduction in South America.

In North America, for example, the extinct animals include the American mastodon, the Colombian, woolly, Jefferson's, imperial and pygmy mammoths, the tapir, the stag moose, two species of deer including the giant deer, the plains camel, the llama, the native American horse, the large long-horned bison as well as another subspecies of large bison, a species of pronghorn, the Asian antelope, the yak, four species of ox including the shrub-ox and the woodland musk-ox, the sabre-toothed and scimitar-toothed cats, the cheetah, the spectacled and giant short-faced bears, the dire wolf (a giant wolf), the giant beaver (the size of a black bear), two species of peccary (related to swine), the anteater, the glyptodon (one of the largest ancient armadillos), and various ground sloths including the Shasta (the smallest, but still the size of a black bear), and the giant (the size of an elephant); and non-mammalian extinctions include that of the giant tortoise.[2]

After such decreases in food resources, i.e. at the beginning of the Mesolithic era and a couple of thousand years before the horticultural revolution, humans generally became more omnivorous in their diet, killing smaller animals and eating less meat. Their stature decreased by about five centimetres, and the size of their population began to diminish, at least in Europe.[3]

### *VCP Explanation of the Cro-Magnon Era*

On the VCP, the spurt in innovativeness about 100,000 years ago was the result of many factors. One was of course *Homo sapiens'* greater intelligence than other human species. Another factor must have been our movement into a new area *north* of where we came from. Thus we did not develop skin clothing in tropical Africa 150,000 years ago, but in the Middle East 100,000 years ago; and we did not learn to create fire until some 40,000 years ago, just prior to our entering Europe. Biologically we are tropical animals, but thanks to our technological innovativeness we have been able to adapt to harsher climates. And this adaptation has of course allowed our population to grow, the acceleration in population growth both 100,000 and 40,000 years ago being partly the result of our colonising new areas.

On the VCP, it was thanks to our technological creative ability that the migrations during our Cro-Magnon stage were possible. This migration was *prompted* by an increase in our numbers also thanks to that ability, and *resulted* in a further increase in our numbers. But this momentum of population growth ran into a wall when we no longer had new areas to move to at the same time as, again thanks to our technological ability, we had eradicated most of our large game.[4]

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[2] Martin (1966), pp. 339 and 340; (1967), pp. 79 and 111; (1973), p. 969, 972–973; (1984), p. 170; Martin & Guilday (1967), p. 20; Baerreis (1980), p. 356; Barnowsky (1989), p. 236; Ponting (1991), p. 35.

[3] Cohen (1989), p. 112; and (1977), p. 126.

[4] Ibid., pp. 14–15.

As regards the demise of large game animals and many of their predators, we see the VCP at work in a very clear form. The technological innovations that allowed humans to expand into new areas provided them with a *surplus* of food, which allowed more people to be fed and led to accelerated *population growth*. This population growth was a contributing factor to the *over-exploitation* of our food *resources*, manifest in the *extinctions* of those species that were the most accessible. With their demise there arose a situation of experienced *need*. And this persistent need, exacerbated by continuing population growth, led to *technological innovation* in the form of more sophisticated weapons that could be used against smaller and more elusive prey.

### *The Horticultural (Domestication) Revolution – 10,000 BP*

Starting around 10,000 years ago, humans began changing their lifestyle from that of hunting and gathering to herding and primitive agriculture. Herding of course took place where there were animals to be herded, and such areas were naturally more arid than those in which actual horticulture was employed.

What perhaps best characterises this time is the move to domestication. Herding is the first step towards the domestication of animals, and the horticultural lifestyle itself involves the domestication of both plants and animals.

As regards plant domestication, the first and subsequently predominant form of horticulture was swidden, or slash-and-burn, cultivation. First, an area of forest was cut down (using newly invented polished-stone axes) and then burned, after which women stuck tubers in holes they made in the area using digging sticks. Each year the productivity of the particular plot would decline, until it was preferable to chop down a new area of forest and start fresh. The original patch would be left fallow to eventually regain its forest character, after which it could again be used for crops.

At this time population growth began to accelerate once again. Despite the fact that human life-expectancy fell from about 30 years for hunter-gatherers[5] to about 20 during the whole of the horticul-

[5] Angel (1975), pp. 182–183.

tural era,[6] during this period the human population increased from some 5–10 million to 80 million.

With increasing population density, however, the length of time a swidden plot would be used before being left fallow increased, and the length of time it was fallow shortened. Longer use of the plot increased the amount of weeds, and the shorter fallow period did not allow the regrowth of forest but only bush, also resulting in increased weeds. This increase in weeds was responsible for the transition within horticulture from the use of the *digging-stick* in *forest-fallowing* to the *hoe* in *bush-fallowing*. Bush-fallowing is physically much more demanding than forest-fallowing, taking a longer time and involving the use of a heavier tool. More work was also required to grind the stone heads of the hoes and other implements needed for this form of horticulture. Eventually bush-fallowing was in many places replaced by *gardening*, where the same plot was used continuously, and crop-rotation was employed to support productivity. This specialised food production meant a lack of flexibility which could lead to starvation when crops failed e.g. as a result of drought.

As mentioned, the horticultural era also involved the original domestication of animals. This began with the dog (from the wolf) some 12,000 years ago or earlier, and was succeeded by goats and sheep around 9000 years ago, then cattle, pigs and bees, and finally the horse and donkey about 6000 years ago. In all these cases the domestic animals were smaller than their wild predecessors.

The domestication of animals led to humans' contraction of many diseases. These include smallpox, brucellosis, malignant boils (anthrax) and tuberculosis from cattle, influenza from pigs, leprosy from water buffalo, the common cold from horses, and measles, rabies and tapeworm from dogs.[7] All told, we now share 65 diseases with dogs, 50 with cattle, 46 with sheep and goats, and 42 with pigs.[8] The effect of these diseases constantly increased with the increase in population density due to population growth, and with constantly increasing trading; and our sedentary lifestyle led to more unsanitary

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[6] Clark (1989), pp. 84–85.
[7] Cf. McMichael (1993), p. 91.
[8] Ponting (1991), p. 226.

conditions which further supported the spread of parasites (including diseases) generally.

*Warfare* was virtually impossible for hunter-gatherers, not only due to their small numbers, but also because of their not being able to accumulate sufficient food to see them through such engagements. (Not that hunter-gatherers did not manage to use their weapons to kill one another anyway, only on a smaller scale.) Thus it was only with the horticultural era, when food could be stored, either as grain or livestock, that real warfare became possible. Furthermore, it was the existence of *property*, any great quantity of which hunter-gatherers lacked, that constituted the immediate cause of war, as well as being a prerequisite for commerce.

Apart from the direct loss of life resulting from such conflicts, warfare also supported female infanticide. By reducing the number of girls in a society, the group could devote its resources to the nurture of its male warriors-to-be. In a survey of studies of 609 horticultural societies it was found that the sex ratio among the young was most imbalanced in those societies in which warfare was current at the time of the study, and most nearly normal in those societies in which warfare had not occurred for more than 25 years. In the former, boys outnumbered girls by a ratio of seven to five on the average, indicating that nearly 30 per cent of the females born in these societies had died as a result of female infanticide or neglect.[9]

During the horticultural period social inequality constantly increased as ever more elaborate systems of social stratification replaced the relative egalitarianism of the past. Slavery was invented; and poverty, crime and war became widespread, while the rate at which humans degraded their environment also increased.

The tools developed during the horticultural era apart from the polished-stone axe and the hoe included sickles, cloth, woven baskets, sailboats, fishnets, fishhooks, ice picks and combs.

### *VCP Explanation of the Horticultural Era*

On the VCP, and in keeping with the anthropological and archaeological findings of the past 50 years or so, the horticultural revolu-

[9] Divale (1972), p. 228.

tion was not a change to a better lifestyle made possible by humans' innovative ability, but a change to a worse lifestyle for a relatively and absolutely greater number of people made possible by that same ability. Rather than suffer great dieback when we had over-exploited our food resources – as other species would have – we found a way of staving off such an eventuality through the widespread adoption of horticultural technology.

What this change meant, however, among other things, was a general lowering of the quality of our lives. This was manifest in increased work, a poorer diet, increased killing of other humans through war and infanticide, and a tremendous increase in infectious disease and parasites. Poorer diet and increased disease, and quite possibly the kind of work we had to do, led to a further decrease in our stature,[10] and these factors together with increased killing of humans by other humans resulted in a drastic reduction in longevity.

The VCP is constantly operative, being responsible for the steady increase in work required as we passed through forest-fallowing to bush-fallowing and on to gardening. Thus, thanks to the VCP, while the amount of work increased, it was still possible to maintain a surplus of food, which in turn supported about a *tenfold* increase in the human population during this period, despite the hardships experienced by individuals.

*Population checks*, whether internal or external, or positive or preventive, operate so as to *counteract* the VCP. What we see with the expression of the VCP through the whole of human development is a steady *weakening* of these checks at the same time as the constantly altering conditions and increasing complexity of human society lead to their taking new forms, or to certain forms manifesting themselves to a greater or lesser degree than earlier. *Warfare*, and particularly the female *infanticide* that has accompanied it, is a positive internal check that probably began in the horticultural period and has been with us ever since. The population checks that became weakened during this period were primarily those related to the spacing of children. Where for hunter-gatherers there were some four or five years between births, this spacing shortened noticeably

[10] Cohen (1989), p. 112, n. 32.

with the horticulturists. On the VCP the primary, though not only, reason for this change was sedentism combined with the virtually constant presence of a *surplus*.

So, quite generally, we see the VCP operating through the horticultural era as follows: First there is a situation of experienced *need* for more food resultant upon *population growth* and the *extinction* of food sources during the hunter-gatherer era. This need leads to the employment of *technological innovations*, the most important of which consists in the domestication of plants and animals. This in turn results in a *surplus* of food of *lower quality* than what it is replacing, the acquisition of which demands more *energy* in the form of human *labour*. This state of affairs means a *lowering* of the *quality* of most people's *lives*, while at the same time the surplus provides the basis from which the *population* is able to continue to *grow*.

### *The Agrarian (Ploughed-Field) Revolution – 5000 BP*

The most important technological development after the beginning of the employment of horticultural methods was the invention and use of the plough. The plough (developed from the hoe), and shortly afterwards irrigation, made possible the maintenance and continued growth of the human population. With the plough, seed crops could be grown more widely, largely replacing the hand-planted tubers of the horticulturists. The resultant harvest per unit land in terms of calories increased tremendously. Worldwide, where conditions were suitable, seed cultivation expanded at the expense of horticulture, while at the same time these cereal crops depleted soils more quickly than did the vegetables and fruits of horticultural agriculture.

Though the average age at death did not change notably in the transition to the agrarian period, remaining at about 20 years, such phenomena as the drought and flooding resultant upon changing weather were more widespread in their effects. Similarly, the spread of infectious diseases had a greater impact due to the constantly increasing size of the population and greater interaction between groups, coupled with worsening hygiene. The most devastating instance was the Black Death in the middle of the fourteenth century, which killed about a third of the population of Europe over a period of four years. And just as the human workload grew with the move to horticulture, it grew again with the move to agriculture. Though oxen and later horses were eventually used to plough fields, at the beginning of the agrarian era it was *humans* who drew the ploughs.

With the amassing of greater amounts of property, society became more stratified: there was a greater division of labour, and the distance between the rich – the richest of whom was the king – and the poor constantly increased. Not only did the lower strata have to do more work, but the top stratum had become more powerful, consisting of relatively fewer persons and having larger territories. The vast majority of the population worked as peasants or slaves for the king's personal best interest: they laboured creating the agricultural surplus that constituted his wealth; they built monolithic monuments to his greatness; and they fought in his wars.

For the last 200,000 years, humans' adaptation to their environment has taken the form of cultural and genetic change rather than chromosomal change, the last chromosomal change being the evolution of modern man. With the development of commerce and warfare much of that cultural and genetic change has consisted in adapting to the activities of other humans rather than to nature. By the time we reached the agrarian period we no longer had to fear other predators, and for the most part had a dependable source of food through the domestication of plants and animals. Thus major successes consisted in the results of exchanges on the market or on the battlefield, rather than in the results of the hunt.

As regards war, the conquest of other people became a profitable alternative to the conquest of nature. Beginning in advanced (metal-using) horticultural societies and continuing in agrarian, almost as much energy was expended on war as in the more basic struggle for existence. At the beginning of the agrarian era, the time of year after the harvest was in was known as 'the season when kings go forth to war.'[11] War was a regular part of life. Here the development of bronze weapons, and later steel weapons, each played a key role.

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[11] L. Woolley, cited in Lenski et al. (1995), p. 181.

The first kings of cities were originally those lords of villages who had an advantage when it came to such weapons.

Nature gradually became less the 'habitat' of the farmer and more a set of economic resources to be managed and manipulated by those in power.[12] With this continual distancing of nature from humankind came a change in our conception of the world, with reality increasingly being thought of in terms of people and their actions.

While the quality of humans' lives declined, so too did the quality of the land. The removal of trees – eventually with the aid of iron axes – to allow the creation of fields led to soil erosion, a process accelerated by the exposure of the topsoil to wind and rain by the use of the plough. In areas which were too hilly or deficient in nutrients for agriculture, goats were let roam, in effect exterminating all but the hardiest bushes. The results of these activities remain with us today, and can be seen, for example, over the whole Mediterranean area. The use of irrigation to increase or make possible the supply of water to fields led to salinisation, leaving the soil unusable for cultivation for thousands of years – as can be witnessed today in the Tigris-Euphrates valley. Wastelands developed around cities, where the area was picked clean of fuel and building materials, and vegetation disappeared due to pedestrian traffic.

As regards other species, the spread of agriculture and the human population forced many from their natural habitats, and some were driven to extinction. For example, around 200 BC the lion and leopard became extinct in Greece and the coastal areas of Asia Minor, and the trapping of beavers in northern Greece led to their extinction. Somewhat less than 2000 years ago, the elephant, rhinoceros and zebra became extinct in North Africa, the hippopotamus on the lower Nile and the tiger in northern Persia and Mesopotamia. Whales were hunted to extinction in the Mediterranean before the fall of the Roman Empire; the crane became extinct in the 1500s; and the last wild ox was killed in 1627.[13]

As in the horticultural period, in the agrarian era one internal population check was infanticide in the face of the threat of severe deprivation. When crops failed and famine was imminent, families

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[12] Roberts (1989), p. 128.
[13] Ponting (1991), pp. 161–163 and 187.

often abandoned their new-born by the roadside, or left them at the door of a church or monastery in the hope that somebody else might raise them. Sometimes even older children were abandoned by their parents. The story of Hansel and Gretel is based in the reality of scarcity. In some districts in China as many as a quarter of the female infants were killed at birth – signs were put up near ponds, "Girls are not to be drowned here."[14] Female infanticide at such a level was not exceptional in such cultures, but, in conjunction with annual warfare, was rather the *norm*. Other population checks included setting minimum age and capital requirements for marriage, and the directing of adolescents into religious careers as priests or nuns.

The length of the agrarian period was extended by the discovery of America, which also allowed a continuing increase in the size of the human population through emigration from Europe. At the same time, however, population also increased in Europe, partly due to the taking of resources from the New World.

The technological innovations of the agrarian period included, besides the plough and iron axes, such inventions as the potters' wheel, the wagon wheel, animal harnesses, horseshoes, stirrups, the lathe, the screw, the wheelbarrow, the spinning wheel, printing, and watermills and windmills. From 5000 to 250 years ago the human population increased from about 80 to 790 million, thanks primarily to agricultural innovations, which increased the number of calories available for human consumption while at the same time reducing the productivity of the land.

### *VCP Explanation of the Agrarian Era*

With the beginning of the agrarian era, the vicious circle of population growth, technological innovation, and resource depletion was about to be traversed once again, and on a massive scale. According to the VCP, the agrarian revolution was a result of the same forces as brought about the horticultural revolution. The need for more food on the part of a constantly *growing population* led to the *invention* and *use* of such tools as the plough and the technology of field agri-

[14] R. K. Douglas, cited in Lenski et al. (1995), p. 199.

culture, including irrigation. The result was once again a tremendous increase in the quantity of food, giving rise to a *surplus*, which in turn supported a further increase in population. And this increase continued throughout the agrarian era thanks to the continual invention of new technology, allowing *ever-increasing quantities of resources* to be taken from the environment, either directly or indirectly, providing on the whole the maintenance of the surplus. Technological development continued to be, not the result of a seeking after a better life, but the response to experienced need resulting from the presence of increasing numbers of people.

With this increase in production and population came an increase in *resource depletion*, mainly in the form of the leaching and salinisation of agricultural soil, the extermination of some species of animals and a reduction in the populations of others, and an *increase in the production of waste. Social stratification* increased further due to the technological innovations' involving improved communication and weapons; and while the poor continued to live lives of drudgery, *infectious diseases* and the presence of other parasites increased among the powerful and the weak alike – though better nutrition, hygiene and living conditions would have made these effects less severely felt among the powerful.

*War* increased partly as the manifestation of a check to the ever-growing population, becoming more pervasive and on a larger scale with its growth. Likewise *infanticide* continued, further checking population growth, the employment of both sorts of check being morally obligatory,[15] just as killing in war is still morally obligatory today. But primarily as a result of the magnitude of the agrarian surplus, these checks, in combination with other checks related e.g. to marriage customs, failed to curb the continuing growth of the population.

### *The Industrial (Fossil-Fuel) Revolution – 250 BP*

With the industrial revolution came not only a huge increase in the use of machines, but a similar increase in the use of fossil fuel –

[15] A conception of the biological basis of morals in keeping with the VCP is presented in Dilworth (2005).

more particularly coal – to power them. In Britain, around 1750, the growing population, among other things, led to a shortage of both land and wood, the latter being used as a building material and a fuel. The possibility of using coal as a substitute fuel for wood was hindered by water constantly seeping into the coal mines. This problem was overcome through the invention of machines – first the Newcomen engine, and later Watt's steam engine – to pump the water out of the mines.

Coal is an inferior substitute for wood as a fuel, a fact which required the invention of other devices and processes such as the use of coke (derived from coal) as a substitute for wood-charcoal in the iron-smelting process – the over-use of charcoal having been a major cause of the dearth of wood. With these changes and the implementation of Watt's engine, the use of coal increased tremendously.

Since coal only existed in particular places, it was necessary that a means of distribution be found. This means involved the invention and use of steamships and locomotives, the construction of canals and railways, and the development of hard surfaces for roads.

The industrial revolution also brought with it a worsened situation for labourers. Instead of working out of doors or in cottages and enjoying the many holidays of the agrarian year, people worked in mines or factories for longer hours at more monotonous tasks and with virtually no holidays. Unlike in the case of farming, mechanised work can be done throughout the year, and with artificial lighting even at night. Child labour also increased, with children being used, for example, in mines, where they could squeeze into spaces too small for adults. The quality of clothing also became lower, with cotton largely replacing linen, wool and leather.

Migration increased from the less-developed to the more-developed areas, from the country to the city. And afterwards, as improved transportation opened up the colonies, there was a massive migration to the Americas and Australia.

In the United States the transition to steam power and the use of coal as a fuel did not take place until there were local wood scarcities and shortages of sources of water power. Quite generally, Americans used less-sophisticated technology when they could, even though they were familiar with the alternatives. They clothed themselves in furs and leather rather than woven cloth; they used wood rather than coal, water power rather than steam, and herding (ranching) and primitive extensive agricultural methods rather than the more intensive European methods they were already familiar with.[16]

Since the industrial revolution *wars* have become larger and more destructive, with larger armies and more powerful weapons, the latest on the list of weapons being nuclear devices. The twentieth century involved greater destruction and loss of life from war than any previous 100-year period.

Trade has also increased tremendously during the industrial era, and is still growing. The increasing production of goods incumbent upon technological innovation and the use of fossil fuels has been disbursed to markets near and far thanks to such innovations as fuel-powered ships and aircraft.

As mentioned, the technology of the industrial era has been operated using huge quantities of fossil fuels, the second of major importance being *oil*. It is the use of these non-renewable fuels more than anything else that perhaps best characterises the industrial era. Where coal began to be used when wood became scarce, petroleum began to be used in response to a scarcity of whale oil. At present, 77 per cent of the energy used in the world comes from fossil fuels, about 33 per cent from oil (the extraction of which will peak in the near future), 26 per cent from coal, and 18 per cent from natural gas.[17] And the rate of use of fossil fuels is almost five times what it was 50 years ago, in spite of international recognition of the many environmental evils to which their use gives rise.

Furthermore, oil is used in the making of a myriad of synthetic products, including most forms of plastic and an ever-increasing proportion of textiles, both of which are invariably of inferior quality to what they are replacing. In the case of textiles, just as cotton became a substitute for linen, wool, and leather during the industrial revolution, we are today witnessing the substitution of oil-based synthetic products for cotton. And where the members of a family could once clothe themselves in woollens and leather using their own raw materials, we are now dependent for clothing on oil wells,

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[16] Cf. Wilkinson (1973), pp. 171–172.
[17] von Weizsäcker et al. (1997), p. 251.

oil tankers, refineries, the chemical industry, textile-machinery manufacturers, and the metal and power industries needed to back them up. The same goes for our food, heating, transportation and almost every other item we consume.[18]

The increase in the production of goods during the industrial period has also meant an increase in waste products. These include not only the goods themselves when they are no longer of use, but the pollution resulting from the burning of the fossil fuels used in their manufacture and operation. And where the animal domestication of the horticultural revolution led to a tremendous increase in infectious diseases among humans, the pollution resultant upon industrialisation and the chemicals used in production have led to a similar increase in cancer.

Extinctions of other species either directly or indirectly due to the activities of humans continued into the industrial era. For example, the osprey, which was common in the 1700s, was hunted to extinction in the 1800s. The great bustard became extinct by 1838. The last pair of great auk, a flightless seabird, was killed in Iceland in 1844. The sea eagle was still common as late as the 1870s, but is now extinct. The Bali tiger became extinct in the 1940s; the Caspian tiger in the 1970s.[19] The human-related wave of extinctions that began in Palaeolithic times and has been accelerating ever since is one of the six greatest in the history of complex life on earth, and the greatest since the extinction of the dinosaurs 65 million years ago.[20]

The technological innovations during the industrial era include farm machinery, pesticides and fertilisers. Other innovations include all machines used in manufacturing, as well as such better-known inventions as the telephone, the electric light, the radio, television, the automobile and the aeroplane. Many of these innovations have been dependent on the prior invention of the internal combustion engine.

The industrial era also brought with it a further increase in the human population, a truly tremendous one which is still continuing. But where the population of the world has increased by a factor of

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[18] Wilkinson (1973), p. 187.
[19] Ponting (1991), pp. 162–163; and Sessions (1995), p. xv.
[20] E. O. Wilson, as cited in Gowdy (1998), p. 66.

five since the 1850s, its consumption of energy has increased *sixty*-fold during the same period. For the wealthy 20 per cent of the world's population the industrial revolution has also meant an increase in leisure: fossil fuel resources not only constitute a tremendous surplus of energy, but one which is unequally distributed.

### *VCP Explanation of the Industrial Era*

By the end of the agrarian period, about 250 years ago, the vicious circle had taken a gigantic turn, and was about to take one of even greater magnitude. The only way such a huge population as existed at the end of the agrarian era could continue to be supported were if a major new resource could be made available. As it turned out, such a resource existed in the form of *fossil fuels*.

On the VCP, at the time of the industrial revolution the experienced *need* for a source of energy to replace wood led to the *technological innovation* of the steam engine, among other devices, in order to make available *resources* that were previously *inaccessible*. These resources took the form of *coal*, whose non-renewability meant that its *quantity* necessarily began to *decrease*.

As is often the case in the turning of the vicious circle, the solution afforded by the technology making it possible to replace wood with coal was only partial. Though coal could be and was used in the firing of bricks, clay for the making of the bricks was also required.

At the same time, however, we must recognise that to date the most important resources made available by technological development have existed in much greater quantity than the resources they have replaced. Each major turn of the vicious circle through the horticultural, agrarian and industrial revolutions has resulted in a surplus of reserves, thereby not only supporting the then-current population, but allowing it to continue to grow. What is important here from the point of view of the VCP is that the recurrence of such a surfeit of resources has been a matter of chance, and nothing guarantees that technological innovation will make available a sufficient quantity of resources even simply to *replace* fossil fuels when they begin to dwindle or cannot be used for other reasons. On the contrary, as we continue to exhaust our non-renewable resources the probability of finding replacements is constantly diminishing; and our current knowledge suggests that no such new resources exist. The major alternative, that made available by atomic fission, presently supplies only about five per cent of the energy used in the world, and shows itself probably to require as much energy to clean up after as it provides itself – *if* it can be cleaned up after. In any case, even at this relatively low level of energy production, reserves of uranium can be expected to last only a few more decades. And so-called renewable sources of energy, among other things, will never be able to provide nearly as much power as has been provided by fossil fuels; nor, unlike oil but like nuclear energy, will they exist in handy, storable, liquid form. And neither nuclear nor 'renewable' sources of energy can power the machinery or supply the fertilisers and pesticides necessary to maintain the form of agriculture required to feed six billion or more people. This being the case, we can expect that the *next* major revolution in human development (which might be termed the *ecological*) will be associated with the diminution of fossil fuel resources, and that it will be the first such revolution that, rather than result in a *surplus*, will be connected to a general *decrease* in available resources.

As suggested by the VCP, the industrial revolution, with its requirement of greater effort to obtain the newly available resources, also brought with it a lowering of the *quality of life* of the common people. This led to *migration* on their part, first to the cities, where the new technology was being employed, and, when paid work could no longer be found there, to the periphery, i.e. the colonies, taking knowledge of the new technology with them and using it when necessary.

The compelling force of experienced *need* is noteworthy here, for it was not before they felt pressed by need that e.g. Americans began employing the sophisticated technology with which they were already familiar. As suggested by Wilkinson, this should be seen in a broader perspective as a response to ecological pressure. It is the inability of the ecosystem to maintain a particular population level that leads to our employing new methods to further exploit that same ecosystem.

We can extend this line of thinking to the whole development of humankind, and say that the changes associated with that development did not come about immediately upon the invention of new technology, but that new technology was invented and used only when there was an experience of need.

The increase in *war* during the industrial era can be explained on the VCP as the result of a combination of factors, including the constant growth of the human population. However, even though wars have become ever more devastating through the industrial period, their role as checks to population growth has (as yet) been minimal. The reason for this on the VCP is that the tremendous amount of energy available in the form of fossil fuels has, primarily through its application to agriculture, made it possible to support a *growing* population, so that the need for population control has not made itself felt to the same degree as it would have otherwise. Here the role of the powerful in society is also important, for it is they who set the trend, and to date overpopulation has been detrimental only to the weak, while benefiting the powerful.

As we move round the vicious circle thanks to our innovativeness and the existence of resources amenable to that innovativeness, the situation in which we find ourselves becomes ever more complex. This is in large part due to the magnitude of the surpluses – particularly agricultural – our technology has made available. These huge surpluses, first in the form of horticultural products and then grain in the horticultural and agrarian periods, and then in the form of food more generally in the industrial era (thanks to technological innovations in agriculture and fishing), have supported a constantly increasing population. The human population as a whole, like the populations of other species, is genetically adapted to the immediate exploitation of its available resources which, given its size and the nature of human intelligence, has resulted in specialisation and order. This complexity increases as the population grows and the specialisation required for handling the new technology increases.

When it comes to *need*, the increasing complexity and stratification of society has led to the perceived needs of the powerful, wealthy part of the population playing a role much greater than their relative numbers would otherwise suggest. In vulgar terms, it means that the greed (perceived needs) of the powerful far outweighs the basic needs of the weak.

Thus we see through the course of human existence a constantly increasing trend towards the development of technology in response to the perceived needs of the wealthy and powerful. The steam engine was not developed for the benefit of the poor, but for that of the owners of the coal mines. And the influence of the powerful has been such that the worldview in which their perceived needs may be met has come to be shared by the weak. Thus we see today, for example, a general acceptance of the need for *economic growth* – which benefits the powerful – despite the fact that common sense indicates that such growth cannot continue indefinitely (in terms of the VCP: it requires the existence of a *surplus*), and that its continued pursuit will only worsen the situation that arises when it is no longer possible.

That economic growth has been possible through the whole of the industrial era is due to the availability of huge though finite quantities of fossil fuels. This has taken the form of the constantly increasing production and construction of material artefacts, which in turn has not only meant a reduction in resources, but when applied to agriculture and housing has prompted population growth and has more generally resulted in ecologically regressive changes, including constantly increasing pollution.

In sum, during the industrial era the vicious circle has moved from the experienced *need* of a particular *resource*, namely *energy*, to *technological innovation*, making that resource available, to the *exploitation* and consequent *depletion* of the resource, which provides a *surplus* of available energy, which leads to *population growth* and *war*, and *economic growth* and *increased consumption*, and on to *increased waste*, and finally to an impending period of *need*.

The human population has increased from about 790 million in 1750 to over six billion today. Virtually the whole of this almost eightfold increase is being maintained by the use of fossil fuels to increase agricultural production and housing. When this non-renewable source of energy is no longer available in increasing quantities, either because of the environmental effects to which its use gives rise, or because it begins to become exhausted, the world will be facing a situation in which billions of people will experience real, basic need, a need which will only be reduced through a drastic reduction in the size of the human population – or eventually be eliminated through the extinction of the species.

## 3. CONCLUSION

The theory of human development provides a coherent view of the whole of the development of humankind. Each of the major revolutions we have undergone can be understood against the background of the VCP, as can the intervening stages involving population growth, war and energy use, as well as the phenomena of resource depletion and environmental destruction.

According to the theory, we humans are developing in a way that is clearly unhealthy as regards our survival as a species. We are headed towards a dead-end, and it may be that only by shifting to a fundamentally different worldview – to a worldview which would do well to incorporate the vicious circle principle – that we will feel sufficiently motivated to begin taking real steps in a healthier direction.

APPENDIX II

# THE DEMARCATION OF MODERN SCIENCE FROM MAGIC, ASTROLOGY, CHINESE MEDICINE AND PARAPSYCHOLOGY

Given the way of conceiving of modern science presented in this volume, namely as an epistemological endeavour emanating from a core of particular ontological metaphysical principles, whether some particular such endeavour is scientific will depend on just which ontological principles it presupposes.

It seems to me that this way of approaching the question of what is or is not (modern-)scientific is much more realistic than e.g. empiricist and Popperian alternatives. For example, the view that science is based on such principles as verifiability or falsifiability (which are *methodological*) is, among other things, unable to account for the fact that many subjects whose results are verifiable (or confirmable) and/or falsifiable in the everyday sense are nevertheless not considered to be parts of modern science, and that many elements that *are* accepted as being parts of modern science, such as hypothetical theories, are neither verifiable nor falsifiable.[1]

On the view developed in the present volume, the principles from which modern science emanates are those of uniformity, substance and causality, each of which is given a physical interpretation. Thus we can look at such practices as astrology and Chinese medicine to see whether they can be considered to be sciences in the same sense as modern science by comparing their ontological presuppositions with those of modern science. In what follows of this appendix I

[1] To this it may be added that the empiricist notion of confirmation is inherently flawed, and that Popper's conception of falsification is incoherent for reasons having to do with an inconsistency in his philosophy of science; overlooking this inconsistency, Popper's philosophy of science nevertheless leads to scepticism: in these regards see my (2007), pp. 9, 11–14 and 38. Furthermore, even a coherent notion of falsification is not only inapplicable to theories but also to empirical laws: in the latter regard, see *this volume*, p. 82, n. 13.

shall make such a comparison, which should show not only that such practices *are* fundamentally different from science – as our intuition would suggest – but that the *extent* to which they differ can also best be understood in terms of their differing ontological presuppositions.

## 1. MAGIC

Belief in magic seems to be a stage virtually all human cultures have gone through or are going through. It includes such beliefs as that there is an all-pervading magical animus that manifests itself in various ways and at various places under certain conditions, some of which are controllable. Thus a person who believes in magic would believe e.g. that under particular circumstances one can influence distant events by manipulating a surrogate of that in which the influence is to be manifest (e.g. that it is possible to hurt or kill someone by sticking pins in an effigy). He or she might also believe that dealing in a certain physical way with something someone has come in contact with (under appropriate conditions), such as a piece of clothing, will have a physical effect on the person in question.

Magic, unlike modern science, is concerned with *getting things done*, and in this regard resembles *technology*;[2] or, if it is assumed actually to work, is in this regard a *form* of technology.[3] Noting this, we recognise that belief in magic nevertheless presupposes particular beliefs regarding the nature of reality. Various attempts have been made in the literature on magic to express these beliefs in terms of what have been called the *principles* or *laws* of magic,[4] which are principles in the same sense as this term is used in the present work. More particularly, they are ontological principles concerning the nature of reality, including how it operates.

According to Marcel Mauss, magic rests on *three* principles, all of which are such that causes can be transmitted along a *sympathetic chain.* These are the principles of *similarity*, *contagion* and *opposi-*

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[2] Mauss (1950), p. 141.

[3] According to Paul Masson-Oursel, the *first expression* of technology (Ellul, 1964, p. 25).

[4] Best known to me in this regard are the efforts of E. B. Tylor (1871), Sir James Frazer (1922), and Marcel Mauss (1950).

*tion*: action on like produces effects on like; things that have been in contact share the same essence; and action on opposites produces effects on the other.[5] By taking these three principles together we obtain what Lawrence Jerome and others[6] call *the principle of correspondences.*

### *The Principle of Substance*

Mauss suggests that one particular notion, the essence of which is captured in the Melanesian notion of *mana*, and which may be seen as corresponding to the animus referred to above, is of central importance to magic as a whole. Regarding it, he says:

> *Mana* is power *par excellence*, the genuine effectiveness of things which corroborates their practical actions without annihilating them. This is what causes the net to bring in a good catch, makes the house solid and keeps the canoe sailing smoothly. On farms it is fertility; in medicine it is either health or death. On an arrow it is the substance which kills . . . .
>
> [A] concept [like that of *mana*], encompassing the idea of magical power, was once found everywhere. It involves the notion of automatic efficacy. At the same time as being a material substance which can be localised, it is also spiritual.[7]

Mana is a kind of magical *potential*:

> What we call the relative position or respective value of things could also be called a difference in potential, since it is due to such differences that they are able to affect one another. It is not enough to say that the quality of *mana* is attributed to certain things because of the relative position they hold in society. We must add that the idea of *mana* is none other than the idea of these relative values and the idea of these differences in potential. Here we come face to face with the whole idea on which magic is founded, in fact with magic itself.

According to Mauss, not only is the idea of mana more general than that of the sacred, but the sacred is a species of mana. Thus, as

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[5] Cf. ibid., p. 64.
[6] Cf. Jerome (1975), p. 43.
[7] Mauss (1950), pp. 111, 117; next quote, p. 121.

far as magical ritual is concerned, mana is the *substratum of the whole.*[8]

This conception of mana is similar to the category of substance as substratum conceived in its most universal form (so as to include, e.g., Spinoza's conception of God). Its similarity to the scientific notion of substance in particular is suggested by Mauss' referring elsewhere to the notion of mana as a category very close to those of *physis* and *dynamis* in Greek thought.[9] On Mauss' description, mana is conceived to be inherent in the world of magic in a way similar to that in which energy is today conceived to be inherent in the world of modern physics. Both notions have causal aspects, and both are intended to refer to something the total quantity of which remains constant, but whose distribution is constantly changing. A difference between them, however, is that while on the scientific metaphysics everything physical *is* energy, on the magical metaphysics mana is not *identical* with what is, but is *immanent* to it.[10] And, of course, mana is essentially spiritual, while energy in science is physical.

### *The Principle of Causality*

In modern science the principle of causality, which states that change is caused, is refined to be the *contiguity* principle of causality.[11] Note the difference between *contagion* and contiguity. According to the contiguity principle, there is no time or space between a cause and its effect, the most common example being the everyday apprehension of the collision of billiard balls. This notion can also be applied to causal relations between a non-physical subject and a physical object, in both directions. Thus we can say, for example, that the mind (subject) is contiguous with that part of the body, e.g. the brain (object), that it is supposed to affect, and that brain states are contiguous with the mind states we may conceive of them as causally influencing.

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8 Ibid., p. 119.
9 Cf. ibid., p. 117.
10 Ibid., p. 111. This distinction is reminiscent of that between the real essences of the chemical elements as compared to those of biological species: cf. *this volume*, p. 156.
11 Cf. ibid., pp. 59&n.–60 and 101&n.

Modern science has had great difficulty fulfilling the demands of the contiguity principle. As a consequence, a weaker principle, that of *proximity*,[12] has generally been accepted. According to the proximity principle, the nearer a cause is in space (or time, though not paradigmatically) to its effect, the greater the effect will be. An example is that of Newtonian gravitation, in which the cause (attraction) stretches out through empty space, and is stronger (according to the inverse-square law) the nearer the object is upon which it has an effect. All the same, proximity has never been accepted as completely satisfactory in science, as is evident e.g. from the fact that physicists are still attempting to find a means by which gravity operates by contiguity.[13]

Thus we can see magic as being similar to modern science in presupposing a principle of causality, but differing with regard to the form that causality takes according to its principle. According to the paradigmatic modern-scientific notion, causes are not only contiguous to their effects, but are also *efficient* and *physical.*

The scientific principles of contiguity and proximity may be contrasted with both the similarity principle and the contagion principle of magic. Given similarity, the requirement of contiguity need not be met. The place where the effigy exists when it is pricked may be far distant from the place of the pricking's anticipated effect.

Similarly, the contagion principle of magic also allows action at a distance, though it at the same time requires contiguity, but of a weakened sort. The contagion principle, in distinction from the contiguity principle, allows that the occurrence of the spatial contiguity *precede* that of the cause-effect action. The physical entity contiguous with the intended object was so at one time, but not at the time when the magical cause – e.g. the burning of the entity – is to give rise to its effect.

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[12] Cf. ibid., p. 60. It may also be noted that the acceptance of non-locality in quantum mechanics would suggest that there, at least, not even the proximity principle is met, and we would have an instance of pure action at a distance in the core discipline of modern physics.

[13] In this regard, cf. ibid., pp. 101–102. As expressed by D. R. Griffin, the desire still exists today "to find explanations of gravitation that do not involve attraction at a distance, such as curvature of space and 'gravitons.'" (1996, p. 94).

The human sciences accept the modern-scientific notion of causality but admit another notion as well, namely that of causes having an *intentional* or *teleological* (rather than *efficient*) ground in human *agents.*[14] Magic accepts these two notions and admits a *third*, which is that of acts performed by agents which are *not* contiguous with their effects. In other words, as already noted, magic accepts *action at a distance* by a *subject* (agent).[15] In fact it may be said that this notion of causality is *paradigmatic* for magic. Thus we see that the principle of causality for magic differs from that for modern science both in its conceiving of causally active *subjects*, as do the human sciences, and in its accepting pure action at a distance, which the human sciences do not. And on top of this we might mention that while interest in causality for modern science is purely *epistemological*, for magic it is *utilitarian* (magic as a form of technology).

### *Distinct Applications of Intention*

As regards the linking of the situation in which the cause takes place to that in which the effect is to take place, E. B. Tylor has suggested that what is important is that *some* association can be seen to exist between the two, i.e. that the principle of correspondences can be applied. As expressed by Mauss, the seeing (making) of this association is "accompanied by [among other things] direction of intent."[16] Thus the practitioner *intends* that there be an association or correspondence between the surrogate of an object and the object itself. Here the notion of intention can be meaningfully applied only

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[14] Cf. *this volume*, p. 140.
[15] As regards this notion of action at a distance, it should be pointed out that even in magic various means of operation have been envisaged which may avoid it. For example there is the idea of *effluvia* which leave the body, magical images which travel about, and lines linking the magician and what he acts upon; even his soul can leave his body to perform magical acts (Mauss 1950, pp. 72–73). It might also be possible to conceive of magical effects' being transmitted through some ubiquitous or immanent magical stuff such as mana. In this way the performance of an act intended to have an effect on something or someone far distant might be seen as a matter of touching on the magical essence of reality, and directing it in a certain way.
[16] Ibid., p. 68.

if we assume that the relevant correspondence does not in fact exist. This application of intention I shall call the *first kind* of application.

The *second kind* has already been mentioned above; it is manifest when the magician *acts* so as to create a particular effect. Thus his or her *intention* is that by acting on the surrogate in a particular way, an effect will be brought about in the object.

Note the position taken in the Western worldview of today with regard to this second kind of application, namely that there do exist intentional or teleological causes as are treated in the human sciences (otherwise, for example, ethics and the idea of responsibility would make no sense), while the spiritual action at a distance believed to be possible in magic is considered impossible – despite our admission of *physical* action at a distance, albeit in keeping with the proximity principle.

### *The Principle of the Uniformity of Nature*

The principle of the uniformity of nature says that natural change is lawful, and it can take more or less strict forms, the strictest of which is determinism.

In *The Golden Bough* James Frazer suggests that magic is perceived by its practitioners as operating according to a deterministic form of uniformity, such that operations on a surrogate *must* have an effect on (or a tendency to affect) the object:

> Wherever sympathetic magic occurs in its pure unadulterated form, it assumes that in nature one event follows another necessarily and invariably without the intervention of any spiritual or personal agency. Thus its fundamental conception is identical with that of modern science; underlying the whole system is a faith, implicit but real and firm, in the order and uniformity of nature. The magician does not doubt that the same causes will always produce the same effects, that the performance of the proper ceremony, accompanied by the appropriate spell, will inevitably be attended by the desired result, unless, indeed, his incantations should chance to be thwarted and foiled by the more potent charms of another sorcerer.... Thus the analogy between the magical and the scientific conceptions of the world is close. In both of them the succession of events is assumed to be perfectly regular and certain, being determined by immutable laws, the operation of which

> can be foreseen and calculated precisely; the elements of caprice, of chance, and of accident are banished from the course of nature.[17]

Thus, assuming that a deterministic form of the uniformity principle is correct, Frazer says: "the fatal flaw of magic lies not in its general assumption of a sequence of events determined by law, but in its total misconception of the nature of the particular laws which govern that sequence."

Frazer's suggestion of deterministic uniformity in magic, which was not adopted by his predecessor Tylor, seems however to have been rejected in the literature,[18] it now being thought that magic presupposes a weaker version of uniformity, of the sort as is normally presupposed in conceiving of intentional action (e.g. by Aristotle and in the human sciences), and as is not to be found in the core disciplines of modern science.

While the form of uniformity presupposed in magic may be weaker than that of the deterministic uniformity principle paradigmatic for modern science, the key differences of principle between the two endeavours concern the principles of *substance* and *causality*, where integral to magic is the idea of *spiritual* substances capable of *acting at a distance.*

## 2. ASTROLOGY

According to such authors as Mauss[19] and Jerome, astrology is a form of magic. This view is supported by looking at the two enterprises in terms of their core principles. According to Jerome, what makes astrology in its modern, i.e. Hellenistic, form a system of magic is essentially its adoption of the principle of correspondences.[20]

Emending Jerome's reasoning somewhat, I suggest that we can see the operation of the principle of correspondences in astrology if we compare the relation between a *surrogate* and the intended *object*

[17] Frazer (1922), pp. 48–49; next quote, p. 49.
[18] Cf. e.g. Tambiah (1990), pp. 52–53.
[19] Mauss (1950), p. 46.
[20] Jerome (1975), p. 37.

of a magical operation with the relation between a particular constellation or planet and particular human beings. In each of these cases the relation involves a particular correspondence which either *paves the way for* (magic) or *constitutes* (astrology) a causal link between the two. The situation is somewhat complex, since we have to do both with the relation between e.g. a constellation and a particular person, and with the astrologically relevant qualities they each have. I am inclined to say that the correspondence might best be thought of as existing between the constellation and the person *thanks to* their respective qualities, though I expect an argument could be made for the correspondence being thought to exist between the qualities rather than their bearers. In any case, assuming that there in fact exists no real such correspondence, it is the *intention* (first kind of application) of the believer in magic or astrology that puts it there (as an 'intentional object').

The two cases differ however with respect to the second kind of application of intention. Where the magician intends to bring about particular effects e.g. through the power of his or her will, in the case of astrology this use of intention is absent. This difference is expressed by Jerome as follows: "In most sympathetic magic, the magician's strength of will is supposed to complete the magical link between amulet and corresponding object; only in astrology is the magical link made automatically through the 'celestial harmonies of the spheres.'"[21]

As regards the first kind of application, on the other hand, the parallel is clear. The correspondence assumed to exist between an effigy and an object in magic is of essentially the same sort as between a constellation and a person (or persons) in astrology. And to this we can add that an integral part of astrology, like magic, is the employment of the notion of action at a distance.

But, as is manifest in their different applications of intention, where magic might be considered a form of technology (or an attempt at a form of technology), astrology is so only indirectly. The magician, through particular manipulations, believes himself able to bring about particular effects. The astrologer, through certain divina-

[21] Ibid., p. 43.

tions, can only indicate predetermined causal relations. The astrologer cannot manipulate the influences himself, or make them act or cease to act. Nevertheless, these influences are not immutable: being aware of them can in certain cases allow one to avoid or deflect them.

I should say that the core principles of the astrological worldview or perspective are radically different from those of modern science. The modern conception of the earth's non-special place in the universe is quite in keeping with the metaphysics of ancient atomism,[22] which in turn is the fundamental metaphysics of modern science. Astrology, on the other hand, is based on a metaphysics that is more similar to Aristotle's. Like Aristotle, astrology both takes the earth to be at the centre of the universe and admits causes that transcend the purely physical – in the case of human action, more particularly *teleological* causes.

Thus if we look at the basic principles of modern science and compare them with what might be considered to be the principles of astrology we should see clear differences. Let us begin with the *uniformity* principle. In modern science this principle applies only to physical entities, so in the case of astrology we must admit that this requirement is not met, since astrology also has to do with non-physical correspondences and self-willed spiritual entities (human agents). But as regards uniformity itself, the difference is not so great. Just as in the paradigmatic deterministic view of modern science, on the astrological conception the influence of the heavens on people's characters is constant. And, where the spiritual influences of the heavenly bodies can be diverted, so can deterministically acting causes in modern science – though in science this in itself requires the concept of a spirit (of e.g. an experimenter) to so divert them.

As regards *substance*, there appears not to be any substratum for astrology, unless one takes the realm in which the spiritual forces of the heavens exist (perhaps what Jerome refers to as the 'celestial harmony of the spheres') to be a substratum. In any case, unlike modern science, astrology admits spiritual substances.

[22] Cf. Lindsay (1971, p. 360): In Roman times "[o]nly the Epicureans made a consistent effort to build a world-picture from which astrology was excluded."

As regards *causality*, whether or not one takes astrology to be a form of magic, we have a situation similar to that in the case of magic, where causes can emanate from spiritual entities, as well as act at a distance.

## 3. CHINESE MEDICINE

Chinese medicine, like any medicine, is distinct from modern science and other purely epistemological activities in that its primary aim is not to gain knowledge or understanding but to *heal* or *prevent illness*. Like magic, its purpose is thus utilitarian, and, to the extent that it works, it may also be seen to be a form of technology. Nevertheless Chinese medicine, like both magic and modern Western medicine, presupposes certain principles regarding the nature of reality and how it operates, and can on this basis be compared with modern science. In this regard we might first note that the categories most central to the fundamental presuppositions of Chinese medicine are those of *qi*, and *yin* and *yang*.

Qi, variously translated as 'vital energy' or 'vital substance' (note the implied animism), is central to all aspects of traditional Chinese medicine; and the same can be said of the distinction between yin and yang.[23]

As regards yin and yang:

> The basic concept . . . is that everything in the universe follows an alternating cycle, e.g., day into night, growth into decay. Although each phenomenon is opposite, each also contains an aspect of the other . . . . In the body there is a continual balance between yin and yang.[24] Yin and yang are interdependent. Extreme yin will change to yang and vice versa.[25]

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[23] Norris (2001), pp. 1, 6.

[24] The idea of health as consisting of a state of balance was the common view in ancient Greece, manifest e.g. in the teachings of Hippocrates and Aristotle, and prevailed in Europe throughout the Middle Ages. The clearest Western correspondent to the yin/yang distinction itself is perhaps Empedocles' opposition of Love and Strife.

[25] Ibid., p. 6. Cf. also Chang (1976, p. 67): The *Nei Ching* states that "[t]he entire universe is an oscillation of the forces Yin and Yang." Here we see that these categories underlie a whole worldview, not just Chinese medicine – just as the central

Yin and yang are thus conceived to be the two main determinants of various types or aspects of qi. Among central such aspects are, in the case of yin, *the solid*, which is produced by the internal organs to nourish the body; and in the case of yang, the *energy* to move the solid, which is the functional activity of the organs themselves.[26] From this point the situation becomes successively more complicated, but all the time with the categories of qi and yin and yang being manifest in various ways.

In Chinese medicine, an imbalance in the amounts of yin and yang is taken to be the cause of all pathology. Thus an ability on the part of practitioners to recognise the aspects of a disease as pertaining in particular ways to yin and/or yang is to help them understand its nature and be better equipped to administer a treatment that leads to recovery.[27]

It is not difficult to see a clear correspondence here with the fundamental principles of modern science. Qi, like the mana of magical thinking,[28] corresponds to the modern-scientific category of *substance*, while yin and yang together correspond to *cause.* In the case of Aristotelian science, yin might correspond to the material cause, while yang corresponds to the formal cause. As regards modern science we might perhaps say that yin corresponds to an attractive force, while yang corresponds to a repulsive force. And as regards *uniformity*, it is clear that a form of lawfulness is assumed in Chinese medicine.

While these similarities exist, there are also of course important differences between the categories and principles of Chinese medicine and those of modern science. Central to the differences is that the latter concern only *physical* reality.

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categories of modern Western medicine are essentially the same as those of the more general materialistic-scientific worldview of our times.

26 Norris (2001), p. 2.

27 Chang (1976), pp. 69, 72.

28 And like the Hindu notion of *bráhman*: cf. Mauss (1950), pp. 116–117.

## 4. PARAPSYCHOLOGY

The two central fields of parapsychology concern what is termed *psi-gamma* (the acquisition of knowledge or information by non-sensory means or without physical mediation) and *psi-kappa* (the affecting of physical objects by a subject without physical mediation). Psi-gamma phenomena include *telepathy* (the sending of thoughts from one mind and the receiving of them by another without physical mediation), *clairvoyance* (knowing independently of sensory input that something is the case), and *precognition* (knowing on non-sensory grounds that something will occur). Psi-*kappa* phenomena are co-extensive with those of *telekinesis*, and include the *psychic healing* of physical ailments. Other aspects of parapsychology concern *out of the body experiences* and *the survival of bodily death*, the first of which may involve psi-gamma, and the second psi-gamma and/or psi-kappa.

### *The Principle of the Uniformity of Nature*

In modern science the uniformity principle is manifest on the empirical level in the *repeatability of experimental results.* That the results of experiments in parapsychology have not been consistently repeatable[29] has consequently been seen as an indication that parapsychological studies ought not be accepted into the realm of science. Note the ontological nature of this line of thinking. It suggests that *despite* parapsychology's scientific methodology, it ought not be admitted to science since its *subject-matter* has not been conclusively shown to follow the uniformity principle.

Though parapsychology, like the human sciences, does accept (a form of) the uniformity principle, the nature of its experiments, involving constantly changing human and animal subjects and an experimenter who is part of the experiment, is such that it is virtually impossible to provide the preconditions for the repeated manifestation of causes in a uniform way. The same may be said of the human

[29] One of the most successful highly sanctioned runs of empirical tests suggesting the existence of psi-phenomena is J. B. Rhine's, where his best subject averaged eight hits per run (chance = five) over a total of 17,250 guesses. (Hyman 1985, p. 45).

sciences however, so in this particular respect parapsychology need be no further from being a modern science than they are. The reason for parapsychology's not having the status even of the human sciences must lie elsewhere. As expressed by H. L. Edge: "Parapsychology fails to be a science for the same reason that voodoology would not be considered a science, and I think it is not because of the lack of replication or prediction."[30] And, as noted above, it is not due to a difference in methodology. As we shall see, as regards its core principles parapsychology is not so different from "voodoology," the fundamental 'failure' to be sciences in both cases being ontological and depending primarily on the principles of substance and causality.[31]

### *The Principle of Substance*

When it comes to the category of substance as substratum, if parapsychology is taken to have such a substance it is clear that it should be more similar to the spiritualistic or animistic substances of magic and Chinese medicine than to the physicalistic substance of modern science. It turns out that parapsychology does have a correlate for

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[30] Edge (1985), p. 61.

[31] Since in this appendix our interest is in demarcating science from non-science, in what follows we shall concentrate on the differences and similarities of parapsychology and modern science. But an important question related to this concerns the viability of parapsychology *per se* with respect to its very *intelligibility.* (Regarding the question of intelligibility in the case of modern science, see *this volume*, Section 5 of Chapter 4.) Thus we might say that where the basic principles of modern science afford an intelligible conception of change, it may not be possible to say the same of the principles of parapsychology. In this general regard Edge, for example, says: "The failure of modern parapsychology is not that we fail to have replication, nor is it that parapsychology studies non-existent phenomena; rather, it is that we have not made our phenomena intelligible. That is why parapsychology is not a full-blown science. Repeatability is only a problem insofar as it has become a symbol for this failure." (1985, p. 64).

At the same time, however, intelligibility presupposes the existence of a particular worldview in the context of which what is being considered is to be deemed intelligible or otherwise; and while it is possible that parapsychological phenomena may not be intelligible against the background of the modern Western worldview, this need hardly be the case if it is considered against the background of e.g. the worldview of magic.

mana, qi, etc., and it is *psi*, of which psi-gamma and psi-kappa are the two fundamental forms. In this regard then we can fairly align psi with mana and qi.

As regards parapsychology and the notion of substance, however, much greater interest has been shown in the question of whether the *self* or *soul* is a substance, such as to imply e.g. that it could survive bodily death. In this case substances are conceived of as being discrete (Platonic) entities rather than as constituting an all-pervasive (spiritual) substratum. A connection might be made between the two conceptions, however, if we were to regard our selves or souls as *participating* in a spiritualistic psi, and each of us as being one of its manifestations.

## *The Principle of Causality*

That we are correct in looking for the criteria for demarcating modern science from other epistemological endeavours on the basis of their respective *principles* finds support not only in others' analyses of magic, but also in C. D. Broad's analysis of parapsychology. In it he compiles a list of what we may consider as candidates for being real fundamental causal principles of the worldview generally accepted today, which he terms "basic limiting principles." These principles are similar to what Thomas Reid presents as the principles of common sense.[32] Antony Flew in fact considers Broad's principles to "have been accepted as items of basic common sense," and furthermore to be "prior to and more fundamental than any named laws of physics."[33]

Broad's principles include that:

1.1. It is impossible that an event should begin to have any effects before it has happened.

1.3. It is impossible that an event should produce an effect at a remote place unless a finite period elapses between the two events, and unless that

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[32] Cf. Reid (1764).

[33] Flew (1987a), p. 37. In this regard, cf. George Price: "The conflict [of ESP with current scientific theory] is at so fundamental a level as to be not so much with named 'laws' but rather with basic principles." (1955, p. 217).

period is occupied by a causal chain of events occurring successively at a series of points forming a continuous path between the two places.

2. It is impossible for an event in a person's mind to produce *directly* any change in the material world except certain changes in his own brain.

3. A necessary, even if not a sufficient, immediate condition of any mental event is an event in the brain of a living body.[34]

Principle 1.1 is more a principle of the modern Western worldview than of modern science,[35] while 1.3 has a close affinity to the scientific principle of contiguity. Principles 2 and 3, on the other hand, with their references to minds and mental events, involve more than is captured by the physicalistic principles of modern science.

Whether or not the soul is taken to be a manifestation of psi, souls or selves in parapsychology are seen to constitute *causes*, as do physical entities – manifestations of substance – in modern science. An important difference however is that in parapsychology, as in magic and the human sciences, the transmission and/or reception of signals are conceived as being the effects of the operation of the *spirit*, not the *body.*

Before proceeding further we might first consider four types of causality or *four categories of cause* (not intended to be either exclusive or exhaustive), all of which we have dealt with earlier, as regards the extent to which they may be considered to be essentially modern-scientific, applicable to the human sciences, and/or applicable to parapsychology. I shall list them here with short descriptions or examples, some of which have already been mentioned above:

A. *Contiguous, efficient, deterministic* and *physical*, such as in the case of colliding billiard balls and Greek atoms.

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[34] Cf. Broad (1949), p. 40; the numbering is Broad's.

[35] The scientific principle of causality does not indicate a temporal direction for cause-effect relations, and in the principle of contiguity the notion of temporality collapses; on the other hand, however, paradigmatic instances of causal mechanisms as conceived in science involve causal chains in which the initial causes precede the final effects. For an exploration of the idea that effects can precede their causes and still be in keeping with the dictates of modern physics, see Faye (1989).

B. *Non-contiguous, proximate* and *efficient*, such as in the case of gravity (so far as we know).

C. *Contiguous, spiritual* and *teleological*, e.g. human action as studied in the social sciences.

D. *Non-contiguous, distant* and *spiritual*, as in magic and parapsychology.

A. *Contiguous efficient deterministic physical causes (and effects).* The paradigm of contiguous, efficient causes on the empirical level, as mentioned in the section on magic, is the collision of billiard balls (cf. also Chh. 4 and 5); and the workings of clocks have also often been referred to in this regard. Such interactions are considered to be *mechanistic* in that they involve the *contiguity* of parts of *substance* in their *uniform (deterministic), efficient*, causal interaction. When such is the case, we may speak of the presence of a *causal mechanism.*[36] Thus we might say that the reason Newton's theory of gravitation does not indicate such a mechanism for gravity is that, despite its depicting uniform change resulting from an efficient cause, it does not represent contiguous action.[37] And, on the present view, Newton's three laws of motion are together taken to constitute his *mechanics* only if they are understood in terms of contiguous action. Here we can also state that, in essence, an *occult quality* is nothing other than a non-contiguous cause; and we can thus understand the criticism of Newton's theory for its having to do with such qualities.

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[36] Cf. *this volume*, p. 101: "In the case where the theory in question succeeds in depicting a regular cause operating via the substance in a way which is in keeping with the contiguity principle, that part of the substance which mediates the causal relation may be termed a *causal mechanism.*" In this regard cf. also Griffin (1996, p. 92): "The new metaphysics for science introduced in the seventeenth century was called, not coincidentally, the 'mechanical philosophy.' [W]e may assume that the chief point at issue in speaking of 'mechanism' was an exclusive focus on efficient causes, in distinction from 'final causation.' The real bite of mechanism . . . is that, by excluding all self-determination, it entails complete determinism. This was indeed one of the central issues, but not the only one. An at least equally crucial meaning of the 'mechanical philosophy' was that action at a distance was proscribed."

[37] *This volume*, pp. 101–102; cf. also p. 205.

Thus the notion of causal mechanism should also cover similar cases in which the interacting objects are not physical (in keeping with Broad's second principle). And, following the discussion of contiguous spiritual-physical causal relations in the section on magic, it would be correct to speak of causal mechanisms operating in the mind, or between the mind and body, so long as the contiguity and deterministic uniformity principles are met. In this way, the operation of yin and yang of Chinese medicine could meet this requirement.

B. *Non-contiguous, proximate causes.* In the section on magic Newtonian gravitation functioned as an example for the application of the *proximity* principle. As was said there, though on Newton's theory the requirement of contiguity is not met, the action of gravity is nevertheless *proportional to distance.* Note that the proximity principle, like that of contiguity, should also be applicable to similar cases where the causes are spiritual, or are a combination of spiritual and physical.

C. *Contiguous, spiritual, teleological causes.* While the human sciences allow spiritual actions to have physical effects, and vice versa, as also mentioned in the section on magic they do not allow action at a distance. As discussed there, and partly covered in Broad's second principle, spiritual causes are to be contiguous with their physical effects in the brain (or body more generally), and physical causes in the brain are to be contiguous with their spiritual effects.

A sub-species[38] of contiguous, spiritual causes consists of those which are *teleological*, i.e. which involve *willing* on the part of an *agent.* The operation of such causes, since it is not deterministic, is such that strictly speaking the notion of a mechanism is not applicable.[39]

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[38] As noted by Donald Evans: "[W]hen changes in consciousness cause changes in the body this is not always an instance of agent causality." (1996, p. 57).

[39] Though it is nevertheless applied when the situation in question is conceived of deterministically, which in itself creates a tension. In this regard, cf. *this volume*, pp. 141&n. and 135, n. 9. The situation is further complicated by the fact that the

On the view presented in this book, the difference between the human sciences and those sciences whose principles lie closer to the core of modern science lies essentially in the human sciences' adoption of a notion of spiritual entities and of causality as stemming from and affecting such entities.[40] I would suggest that it is the fundamental difference of such spiritual entities or agents and physical entities, both in how they are and how they act, that constitutes the fundamental difference between the human sciences and modern science, an ontological difference which no methodology can remove. In terms of principles, it is the basic difference in the principles of *substance* and *causality* that divides the two. Furthermore, the non-deterministic aspect of teleological causality[41] further removes it from the core causal principle of modern science, a problem similar to that experienced by quantum mechanics with its indeterminacy principle.

A question that then arises, however, concerns the acceptance of the uniformity principle on the part of the human sciences and parapsychology. It may appear that the introduction of teleological causes means the forsaking of uniformity. What we find, however, is that the uniformity requirement is met on the empirical level in the consideration of *large numbers* of what are conceived to be teleological cause-effect relationships, which are such that uniformity becomes to some extent evident.

D. *Non-contiguous, distant, spiritual causes.* Thus parapsychology, like the human sciences, differs from modern science in its admitting agent causality; but it is even further removed from science in its not requiring contiguity (unlike the human sciences) nor proximity (unlike physics). More particularly, as regards psi-*gamma*,

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effect of a teleological cause is normally at a distance from the spirit willing that effect, and thus involves a causal chain.

40 Cf. Meynell (1996), p. 23: "In general, we have two kinds of explanation of phenomena: the physical kind best exemplified by natural science, and that involving appeal to conscious agents."

41 This aspect consists in the fact that the striving to attain a particular end does not ensure that that end is actually reached. That an act is *freely willed* does not in itself contravene the uniformity principle *per se*, but suggests rather that there can exist (spiritual) causes that are not the effects of other causes.

the receipt of telepathic or clairvoyant information should be independent of where or when it is sent; and the physical distance between the cause and its effect should be irrelevant.

As regards psi-*kappa*, the question of *temporal* contiguity hardly arises. But as regards *spatial* contiguity, the spiritual cause and its physical effect are normally not spatially contiguous, as when someone is considered to affect the rolling of dice with their minds; and in such cases neither is the proximity principle obeyed. In other cases however, such as those involving psychic healing where light tactile pressure is employed, there appears to be contiguity, while it is nevertheless the spirit that is considered to be doing the healing.

## 5. METAPHYSICS AND WORLDVIEWS

As suggested by James McClenon,[42] and as is the basic presupposition of this book, the methodology of science is based on various *metaphysical* assumptions. That the present question has to do with metaphysics is also expressed by Douglas Stokes, who suggests that *materialism* is a metaphysical doctrine.[43]

The seeing of worldviews as each being based on a particular metaphysics[44] can help us understand not only the considerations of G. H. von Wright cited in the body of this book,[45] but also those of David Ray Griffin where, quoting Jerome Ravitz, he agrees that the "Scientific Revolution was primarily and essentially about metaphysics; and the various technical studies were largely conceived

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[42] McClenon (1984), p. 3.

[43] Stokes (1985), p. 380. Cf. also Mary Hesse, who says, "there is a sense . . . in which basic categories . . . in science are always *a priori*; and the new principles [of the Scientific Revolution] were understood partly as the replacement of the old metaphysics by new, and were argued on metaphysical grounds. [T]he seventeenth century world-model according to which all physical change is *really* produced by matter in motion . . . is in a sense a metaphysic; derived from the Greek metaphysical theory of atomism; established by the overthrow of opposing metaphysical systems, namely the Aristotelian, Stoic, and Neo-Platonic; and justified by the Pythagoreanism of Copernicus, Kepler, and Galileo, and by the metaphysical arguments about primary qualities of Descartes, Galileo, and Locke." (1961, pp. 98–99, 125).

[44] Cf. *this volume*, e.g. pp. 158n., 200, 207–208, and above, pp. 250, 255.

[45] Ibid., p. 61, n. 19; quote following, Griffin (1996), p. 92.

and received as corroborating statements of a challenging worldview." And we can also understand McClenon's seeing a coupling between the a priori of metaphysics and the notion of a worldview, together with his suggesting that parapsychology opposes the scientistic worldview of our times, rendering the paranormal as a priori impossible.[46]

## 6. HISTORICAL DEVELOPMENT OF THE NON-PHYSICAL

According to the development of the history of ideas as presented in Chapter 10 of this volume, "three streams of Greek philosophical thought have shaped virtually the whole of Western intellectual development – philosophical and modern-scientific – right up to today." These streams are the Presocratic atomist – from which modern science has developed – the Platonic, and the Aristotelian. Regarding the last two, Broad and Richard Robinson point out that:

> According to the Platonic theory, a man is primarily something immortal and imperceptible and spiritual, which for one or more short periods is united with something mortal and perceptible and material, namely, a specimen of that animal labelled 'homo sapiens' by the biologists. According to the Aristotelian theory, man *is* that animal labelled 'homo sapiens' by the biologists; and that animal is not linked to any immortal imperceptible twin (you see I am disregarding the famous little chapter in which Aristotle reverts to Platonism); and what we refer to as its soul or mind is the entelechy or form or higher behaviour of that animal.[47]

The first major step in the seventeenth-century revolution against Platonic and more particularly Aristotelian thought was the acceptance of Copernican astronomy. With the advent of Copernicanism and the demise of the Aristotelian earth-centred conception of the universe, as has been pointed out by J. V. Field, acceptance of the teachings of astrology also began to decrease markedly.

> The rapid decline in the intellectual standing of astrology in the course of the 17th century is roughly contemporary with a rise in the respectability of Copernicanism. . . . If all the planets, including the Earth, were believed to be

[46] McClenon (1984), pp. 131, 68; quote following, *this volume*, p. 199.
[47] Robinson & Broad (1950), p. 272; next quote, Field (1987), p. 144.

moving round the Sun, the fact that a particular planet was 'in' a particular constellation merely told one something about its position relative to the Earth rather than, as in a geocentric cosmology, its actual position in regard to the Universe as a whole. While this does not refute the ascription of particular 'houses' to each planet, it does somewhat decrease their cosmic significance. Moreover, a similar weakening will be found in all the reasoning which depends upon Zodiac signs: in a heliocentric system we no longer have absolute properties of the macrocosm exerting their influence upon Man.

Once the earth was removed from the centre of the universe the way lay open for the introduction of the atomistic-physicalistic view of the Scientific Revolution. With this revolution we have a shift away from the notion of spirit,[48] one even further than that made in the move to Aristotle's philosophy from Plato's in the Middle Ages. Thus, for example, the Scientific Revolution not only eliminated Aristotelian science, but drastically weakened the position of the Church. As suggested by H. Butterfield, Newton's first law and the modern theory of motion in the seventeenth century helped to drive the spirits out of the world and open the way to a universe that runs like a piece of clockwork.[49] As expressed by Stokes, at this time the universe became a big machine governed by mechanical principles.[50]

That the Scientific Revolution reinforced the principle of contiguity in particular is further supported e.g. by Newton's continual attempts to find a physical link for gravity.[51] And it also gains support from present-day writings such as those of Mary Hesse, who suggests that the idea of action at a distance lost favour through the introduction of the mechanical philosophy of nature, according to which physical particles were purely material, having no sympathies or antipathies allowing them to exert or receive influence at or from a distance.[52] Further support comes from Richard Westfall, who claims that "All agreed that the program of natural philosophy lay in demonstrating that the phenomena of nature are produced by the

[48] The Scientific Revolution's elimination of the idea of what is *animate* as underlying change is emphasised by Hesse (1961, pp. 101, 111–112).
[49] Cited in Stokes (1985), p. 382.
[50] Ibid., p. 383.
[51] Cf. *this volume*, pp. 59 and 102, n. 8.
[52] Hesse (1961), pp. 118, 125 and 291.

mutual interplay of material particles which act on each other by direct contact alone."[53]

As suggested by Griffin, the development of a fully materialistic position by society at large

> occurred in the latter half of the eighteenth century in France and in the latter half of the nineteenth century in the English-speaking world (thanks to a large extent to Darwin). With this development, the 'mind' was fully within nature, being purely a function of the brain (as the notorious Hobbes had suggested), and was therefore subject to the same prohibition against action at a distance as the rest of nature.

There was a backlash to this development, however, manifest in Hermetic and other 'magical' philosophies, which allowed influence at a distance as a purely natural occurrence, including that to and from minds.[54] There was also an upsurge in interest in the two traditional cult sciences of astrology and alchemy, as well as in a wide variety of older and newer systems of magic.[55] And in the academic world, where the metaphysics of atomism had developed into modern science, Platonism and Aristotelianism continued on alongside, and were modified in various ways so as to be in keeping with what science had established while retaining the notion of spirit. Leibniz' philosophy can function as an example. In it his monads are *like* atoms, only they have the teleological properties of Aristotelian philosophy; and his great hope is to invent a universal *language*, to which a formal logic *à la* Aristotle should apply.

Part of this reaction, particularly with regard to the influence of the Scientific Revolution and Darwin's theory of natural selection on the Church, was the rise of spiritualism in the second half of the 1800s – its predecessor being the Shaking Quakers. Mediums had arrived on the scene already around 1770; and with the seances of the infamous Fox sisters beginning in 1848, a spiritualist mania was born.[56]

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53 Cited in Griffin (1996), p. 92; next quote, p. 95.
54 Ibid.
55 John Beloff, cited in Alcock (1985), p. 546.
56 Alcock (1985), p. 548; quote following, Flew (1987b), p. 14.

Essentially this same reaction was manifest at the end of the nineteenth century with the formation of the Society for Psychical Research, the intention of its members being to support a Platonic-Cartesian point of view, which maintains

> that somehow inside and controlling the creature of flesh and blood is a mind or soul or self; and that this is a substance, in the sense that it could significantly be said to survive separately – unlike, say, a personality or a temper or a grin; that this substance is incorporeal, immaterial, and somehow non-physical; and, finally, that it is the essence or core or actual person.

As regards philosophical development, after the Scientific Revolution and up until the twentieth century it consisted in attempts to resuscitate the notion of the spirit in a form in keeping with either Plato or Aristotle while not obviously conflicting with the results of science. This line has continued in the twentieth century and up to the present in the Continental tradition, while independently of it the analytic tradition has developed, consisting in a misconceived Aristotelian-logicist kowtowing to science.

In general the reaction to scientific materialism has been weak, however. The success of modern science has not only meant a general decline in interest in the spiritual, but the acceptance of the principles of science as sacrosanct, thereby discouraging the investigation of fimdamentals, and accounting for the peripheral place of philosophy in our universities.

Given the scientistic spirit which has enveloped us since the time of the Scientific Revolution, we can see the strong emphasis on measurement in the human sciences during the twentieth century as being a manifestation of psychologists' and social scientists' attempts to have their subjects be accepted as parts of modern science, where emphasis is placed on the manifestation of the uniformity principle on the empirical level due to the influence of positivism in the form of behaviourism.[57] This phenomenon is also evident amongst parapsychologists during this same period, in their attempts to create replicable experiments.

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[57] In this general regard, see *this volume*, pp. 130–131.

## 7. MODERN SCIENCE AND THE SPIRIT

The fundamental problem for modern science with regard to the spirit is evident already in early Greek atomism, with its lacking categories for the self and psychic states.[58] This problem remains in modern science, both as a paradox with respect to the nature of its own activities, as well as a major lacuna with respect to what it is capable of explaining. Thus modern science presupposes an agent for its own existence;[59] and at the same time the spiritual element generally acknowledged to exist in human activities cries for explanation. Science, limited as it is to physicalistic categories, cannot handle either of these issues.[60]

As expressed by J. B. Rhine with respect to the latter point, and as is in keeping with what I parenthetically suggested regarding ethics and the idea of responsibility in the section on magic:

> Under a mechanistic determinism the cherished voluntarism of the individual would be nothing but idle fancy. Without the exercising of some freedom from physical law, the concepts of character, responsibility, moral judgment, and democracy would not survive critical analysis. The concept of a spiritual order, either in the individual or beyond him, would have no logical place whatever. In fact, little of the entire value system under which human society has developed would survive the establishment of a thoroughgoing philosophy of physicalism.[61]

Hugo Meynell, for his part, asks:

> How, if at all, does one adapt 'scientific' inquiry, for example, to the treatment of ethical, metaphysical or religious questions? Are the methods of the natural sciences to be extended without modification to what are sometimes called the human sciences? If they are not, what types of modification are needed, and why? Questions like these can hardly be avoided if one is going to consider applying 'scientific' methods to the matters in which we are interested here.

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[58] Cf. ibid., pp. 201–203.
[59] As suggested by Evans (1996, pp. 55–56, 58–59).
[60] As pointed out regarding the latter on p. 91 of *this volume*; cf. also p. 60: the core principles of modern science "can be criticised for difficulties had in applying them to psychological phenomena, conceived quite generally."
[61] Rhine (1954), p. 32; next quote, Meynell (1996), p. 24.

In this regard Stokes suggests that present scientific theory is incomplete when it comes to explaining mental phenomena: "There is no understanding at present of how or why certain patterns of neural activity give rise to conscious experience."[62] I should say that this is not a problem just "at present," but is a problem *in principle*, and lies in the nature of the metaphysical core of science.[63] Elsewhere Stokes suggests that strict materialism contradicts the fact that one has direct experience of such mental events as sensations, thoughts, memories etc., and that psi phenomena threaten the worldview of scientists, which is clung to with almost religious tenacity.[64]

In the same vein, James E. Alcock rhetorically asks how a science of the spirit can exist, given that science by its very nature is materialistic,[65] while B. Mackenzie and S. L. Mackenzie claim that anti-materialism is part of the identity of the paranormal, and that if materialism is incorrect, once this is realised the implications for humankind could be overwhelming.[66]

All of these eminently reasonable opinions can be understood when the essence of modern science is seen to consist in its adoption of particular physicalistic principles, as is suggested in the present book.

## 8. THE PHYSICAL VS. THE SPIRITUAL

As has been advanced in this book, and is supported by the considerations of the present appendix, modern science is an epistemological endeavour whose categories are limited to what is physical. Such subjects as parapsychology might be compared with biology in this regard. Biology is the modern-scientific discipline concerned with *life*, while parapsychology concerns the *spirit.* But since life, like the spirit, lies beyond the categories of modern science, why should biology be a part of science while parapsychology is not? The answer is that biology is only concerned with the *physical aspects* of

62 Stokes (1985), p. 395.
63 The same applies with respect to life: cf. n. 67 below and accompanying text.
64 Stokes (1985), pp. 384–385.
65 Alcock (1985), p. 562.
66 As cited in ibid., p. 559.

life; the notion of life itself is not a category of modern biology.[67] More generally we could say that the only extent to which modern science is capable of dealing with non-physical substances is in terms of their physical aspects or manifestations. Thus, for example, self-willed action can only be the subject of modern-scientific research in the form of physical behaviour.

Conceiving of the situation in terms of *paradigms*[68] leads to the thought that while the core paradigm of modern science is *physicalistic*, it may be fruitful to think of magic, parapsychology and so on as tending to cohere about a core paradigm which is *spiritualistic*, and that the conceptual move from one to the other constitutes a *paradigm shift.*[69] Given this, we should then be inclined to say that just this distinction between the spiritual and the physical, manifest in philosophy for example as the mind-body problem, constitutes the most important epistemological distinction we humans have yet to make.[70] From this one might want to go on to say that it is thus only the physical that can be investigated *scientifically*, whether it be by modern science or some other form of science, and that this being the case constitutes *the fundamental limitation of science.* However, in part due to the honorific status attributed to the appellation "science," I am inclined to use the term in a broader sense so as to include investigation of the spiritual, as long as that investigation is *systematic.* On the philosophy of science being presented in this book it is not being assumed, as it is on the empiricist and Popperian views, that there is but one right way of going about acquiring

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[67] Cf. *this volume*, pp. 149–150, 154, and 206: "But the nature of life itself, and how it differs from non-life or the physical, lies in principle beyond what the physicalistic categories of modern science could ever be able to handle."

[68] Cf. ibid., pp. 51–52&n., 56, 60, 70, 131, 133.

[69] As suggested by S. J. Tambiah (1990, p. 9) in the case of the transition from magical to modern-scientific thinking.

[70] Which is in keeping with my suggestion in Chapter 10 (p. 195) that the move to physicalistic explanation on the part of Thales initiated the greatest intellectual revolution in the history of humankind. Cf. also Price (1955), p. 217: "Rhine has correctly stated that 'Nothing in all the history of human thought – heliocentrism, evolution, relativity – has been more truly revolutionary or radically contradictory to contemporary thought than the results of the investigation of precognitive psi.'"

knowledge (or understanding) of reality, that being the *scientific*,[71] such that all forms of epistemological endeavour should conform to it. Here, rather, the possibility of there being different sciences and scientific methodologies is recognised, and no special value is attached to what is accepted as science today.[72]

The ontological approach adopted here, in which sets of principles function as paradigms for their respective subjects, also makes it clear that the difference between modern and non-modern science is not in all cases an either/or issue, but can involve the question of gravitation to a paradigm. This would explain why the scientific status of physics has never been questioned, despite its failure to meet the contiguity requirement with regard to any of the fundamental forces, and its apparent non-determinism and non-locality in quantum mechanics; the reason for its acceptance not being because of its methods, but because of its physicalistic categories. The present approach also explains why we can expect the (modern-)scientificity of the human sciences always to be questioned no matter what methodology they adopt. Further, it explains why, despite the fact that change on the Chinese worldview might be both deterministic and the result of the operation of contiguous causes, it is not accepted as a part of modern science, and why Chinese acupuncture is opposed by the American Medical Association, despite the technique's inductively demonstrated curative and anaesthetising qualities, the reason the Association gives being that acupuncture cannot as yet be explained mechanically.[73] And it explains why, despite the fact that the empirical methodology of parapsychology is strictly modern-scientific, the subject is even less accepted as a science than are the human sciences, as well as why elite mainstream scientists are those who evince the greatest scepticism regarding parapsychology, at the same time as they are the most inclined to cite a priori reasons for not accepting it.[74] The distinguishing feature in all of

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[71] In this regard, cf. *this volume*, pp. 7–8, 61 and 72.
[72] Cf. the reference to Feyerabend's 'methodological anarchism' on p. 70 of ibid.
[73] In this regard cf. McClenon (1984), p. 78.
[74] Ibid., pp. 128 and 144. Cf. also Griffin (1996), p. 88: "Critical reflection about the paranormal is primarily important . . . for the same reason that it has been so difficult: because it challenges the modern paradigm ([i.e.] worldview)."

these cases is the various subjects' inclusion of categories of the spiritual; *this* is what keeps them from being sciences in the same sense as modern science.

## 9. CONCLUSION

Following the metaphysical approach of the present volume, not only can we demarcate modern science from the other epistemological endeavours treated above, but also distinguish it from such activities as mathematics, Western medicine and applied science, as well as from Platonic and Aristotelian science and common sense.[75] Not only this, but given the present approach we can also understand the hierarchy in which physics stands at the top, with, in order, chemistry, biology, the human sciences and investigations of the paranormal under it.

On the basis of the above reasoning then, we come to see that the distinction between modern science and other epistemological endeavours is well characterised when the subjects in question are considered in terms of their core principles. Most important in this respect is whether the substance of the practice in question is physical or not, and whether its causes operate only between physical entities.

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[75] The last two of which receive a detailed treatment in Dilworth (2004).

APPENDIX III

# REPLY TO CRITICISM

In this appendix I shall reply to many of the criticisms that have been made both of this volume as well as of the second and third editions of my earlier book, *Scientific Progress.*[1] I shall begin with the earlier book.

In the mid-1970s, when I began working on the topic of scientific progress, the incommensurability claims of Kuhn and Feyerabend, made in the 1960s, still constituted the central problem in the philosophy of science. The problem was that if scientific theories were incommensurable in the sense intended by Kuhn and Feyerabend, then the logical empiricist and Popperian views of scientific change (and of science more generally) would be seriously undermined: among other things, they would both lead to relativism due to their inability to handle the changes in meaning involved in the move from one of two incommensurable theories to the other.[2]

The response to Kuhn's and Feyerabend's claims on the part of most philosophers was to defend the 'received view' by trying to show the claims to be incoherent and thereby themselves to fail to avoid relativism – but in so doing these philosophers presupposed their own logico-linguistic approach, and the effect of their efforts was really only to show that the notion of incommensurability could not be captured on it.[3] In this regard, however, it is important to note that no one other than Feyerabend attempted to provide an alternative conception of scientific change capable of admitting incommensurability and at the same time avoiding relativism, and that his attempt was not successful.[4] This being the case may have contrib-

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[1] I reply to criticisms of the first edition of *Scientific Progress* in Appendix II to its fourth edition.

[2] In this regard, cf. ibid., pp. 24 and 39.

[3] See ibid., pp. 76–78.

[4] Feyerabend's attempt took the form of his 'pragmatic theory of observation,' concerning which see ibid., p. 79&n.

uted to people's so readily taking both Kuhn and Feyerabend to be *advocating* relativism, and to Feyerabend's possibly later acceding to such an interpretation.[5]

At least partly as a result of this, a line has developed in philosophy of science in which the social aspects of science as treated by Kuhn are emphasised, while science is considered to be relativistic, while at the same time the mainstream view of the 1960s and earlier never solved its problem of incommensurability. Despite this and other major failings (as demonstrated in *Scientific Progress*), this view has continued to be the dominant line in contemporary philosophy of science. But *both* of these views are relativistic – the sociological view intentionally so, and the logico-linguistic view so due to its inability to solve the incommensurability problem, or more generally due to its inability to provide criteria for scientific progress that are applicable to actual science.

If one is to provide a non-relativistic conception of scientific change capable of handling incommensurability, as I attempt to do in *Scientific Progress*, the first question to be answered is what specifically is meant by saying that particular theories are incommensurable. I provide an answer to this question in Chapter 7 of the book, where I present both negative and positive senses of incommensurability, the former based on results I obtained employing the *Deductive Model* in the book's previous six chapters, and the latter as a first step towards introducing my own theory of science. Thus in the first regard I suggest that incommensurability implies that attempts to depict scientific progress based on the Deductive Model are inherently inadequate, and in the second that the gestalt-switch diagram illustrates an important aspect of incommensurability.

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[5] As I point out in *Scientific Progress* (p. 50), Kuhn was not advocating relativism; nor, at least in the 1960s, was Feyerabend. As I also point out there, "many of Kuhn's critics [and, as it turned out, many of his supporters!] presuppose, either wittingly or otherwise, that an account of science as a rational enterprise must take the form suggested by either the Deductive Model or some other formal construction . . . . [Thus] the relativism that arises in [contexts having to do with theory change] has been taken to imply a relativism in Kuhn's and Feyerabend's claims, [whereas] it is rather the Popperian conception that leads to relativism." (pp. 50–51, 53). Concerning rationality and science, see also *this volume*, p. 67, n. 32 and accompanying text.

As regards my own theory, the *Perspectivist conception*, which is introduced via the *Gestalt Model* and developed in the remainder of the book, it is to be noted that, as I remarked already in the first edition, "though the present view has gained much inspiration from the respective works of Kuhn and Feyerabend, it is not being presented as a direct reconstruction of the views of either of them."[6] The Perspectivist conception of science constitutes a philosophical theory that is to be judged on its own merits.

So *Scientific Progress* is devoted to providing a theory capable of both accommodating Kuhn's and Feyerabend's notions of incommensurability (which include the idea of theory conflict but not the Deductive Model) and at the same time avoiding relativism. In the words of Ricardo Gómez: "Dilworth attempts to show that his approach avoids not only the criticisms which Kuhn and Feyerabend level at the received view, but also the charges of relativism which in turn have been levelled at Kuhn and Feyerabend themselves." [7]

## 1. THE DEDUCTIVE MODEL

The Deductive Model of science is an abstraction I made on the basis of studying the writings of Hempel, Popper and others of that generation. This model lies at the core of my explanation of logical empiricism and Popperianism. What is important as regards the model is that, as I try to demonstrate in the book, both views presuppose it, such that all their central concepts can be expressed in terms of it, and all of their problems (including that of relativism) emanate from its use.

David Oderberg, in his review of *Scientific Progress*, suggests that most of my objections to logical empiricism and Popperianism "stem from the model to which these views are wedded," i.e. from the Deductive Model, while at the same time none of my criticisms are original.[8] In this regard I would first suggest not that *most* of my objections to empiricism and Popperianism stem from the Deductive

[6] *Scientific Progress*, p. 67.
[7] Gómez (1992), p. 264.
[8] Oderberg (1997), p. 188.

Model, but that *all* of them do. And I believe that a number of my criticisms are quite original. These include that the logical empiricist and Popperian views are formally identical (pp. 11ff.); that it is impossible for Popper to distinguish science from non-science on the basis of falsifiability once he claims, as he does in criticism of the empiricists, that no empirical statement is verifiable (p. 14); that his notion of corroboration is formally identical to the logical empiricist notion of confirmation, and thereby commits him to induction (p. 17) – for which he also criticises the empiricists; and that he provides no notion of content applicable to contradicting ‘theories’ (p. 34). To this I would like to add that, so far as I know, not only are all of these criticisms original, but they are also *correct*.

But much more important as regards the question of originality is my reconstructing the *whole* of logical empiricism (including my provision of the empiricists with a formal conception of scientific progress)[9] *and* Popperianism in terms of the Deductive Model, a reconstruction showing that both views *are* in fact “wedded” to the model. Oderberg apparently does not realise that this model (as distinct from the deductive-nomological model of explanation) was presented explicitly for the first time in *Scientific Progress* in an attempt to explain these two views, and that the first six chapters of the book are specifically devoted to this effort, which is to function as a lead-up to my own theory.

Gómez appreciates this however, as is clear from his commenting on the excellence of my attempt “to show that those shortcomings and problems [of the logical empiricists and Popperians] are mainly grounded on the shortcomings and problems of a commonly shared deductive model.” Here I would claim that what is “excellent” regarding my attempt is that it is successful, as is evidenced, for example, by Oderberg’s assuming that the empiricist and Popperian views *are* in fact “wedded” to the model.[10] Furthermore, I would suggest that my treatment of the views of the logical empiricists and Popperians in *Scientific Progress* is *definitive.*

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[9] *Scientific Progress*, pp. 20–21; quote following, Gómez (1992), p. 265.

[10] Though reviewers of the second and third editions of *Scientific Progress* apparently appreciate that both logical empiricism and Popperianism do rely on the Deductive Model, some critics of the first edition questioned this.

Since the Deductive Model may be confused with the deductive-nomological (D-N) model of explanation, perhaps the difference between the two should be clarified. The D-N model can be seen as constituting a particular application of the Deductive Model, namely to scientific explanation and prediction. The Deductive Model itself is much more general, and also includes the logical empiricist notions of verifiability, induction, confirmation, progressive theory change, theoretical terms, and correspondence rules; and the Popperian notions of falsifiability, basic statement, background knowledge, corroboration, severity of tests, theory conflict, theory content, probability of a theory, testability, verisimilitude, and the whole of Lakatos' sophisticated methodological falsificationism.[11]

What the underlying identity of the logical empiricist and Popperian views means, among other things, is not only that they are not as different as Popper would have had us believe when he claimed to have 'killed' logical empiricism, but more importantly that both views are *dependent* on the Deductive Model in their respective depictions of the scientific enterprise. The model constitutes the *conceptual paradigm* for both of them, and any notions they advance in attempting to explain the nature of science must be expressible in terms of it.

## 2. THE PERSPECTIVIST CONCEPTION

To my mind, none of my current or earlier critics have appreciated how important the common presupposition of the Deductive Model on the part of the logical empiricists and Popperians is as regards their respective characterisations of science in general, nor as regards the incommensurability of scientific theories in particular. I might also say that few if any mainstream philosophers of science – including my present reviewers – today realise the extent to which they themselves are still ensconced in this logico-linguistic way of thinking.

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[11] In this last regard, as also appreciated by Gómez: "Dilworth correctly emphasizes Lakatos' endorsement of many of Popper's views and, consequently, Lakatos' acceptance of the Deductive Model." (ibid., p. 265).

This may account not only for their general failure to fully appreciate the critical part of *Scientific Progress*, but for their failure to appreciate its positive part as well. Where Oderberg saw little novel in my work with the Deductive Model, Gert König believes the Perspectivist conception itself to be a *summary* of Hanson's, Kuhn's and Feyerabend's "investigations of the fundamental perspectival shifts of science."[12] However, not only is the Perspectivist conception not a summary of anyone else's work, but the notion of perspectival shifts *originated* with it.

Similarly, Hanne Andersen considers the Perspectivist conception to be "an interesting elaboration of ideas which were only briefly introduced by Hanson, Kuhn and Feyerabend."[13] Here Andersen apparently does not realise that it was not my intention to provide an elaboration of other people's ideas, but rather to provide an independent theory of scientific progress which took account of their various claims; nor does he seem to realise that the fundamental ideas of the Perspectivist conception are not to be found in the work of Hanson, Kuhn or Feyerabend.

Andersen also criticises me for not referring to Kuhn's later work and for not discussing the work of such logico-linguists as Scheffler, Putnam and Kitcher, who are supposed also to have had the idea that "differing conceptual perspectives can have the same reference."[14] But in the first case, my interest is not in Kuhn's work *per se*; and in the second, once again, "conceptual perspective" is a technical term that presupposes the Perspectivist conception. If the authors Andersen mentions are in fact speaking about conceptual perspectives (which I doubt), then they are indebted to *Scientific Progress* for the notion.

## *The Gestalt Model*

Regarding the Gestalt Model, Gómez says: "Dilworth believes that to perceive something in a particular way, e.g. as a rabbit (per-

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[12] König (1989), p. 371.
[13] Andersen (1997), p. 265.
[14] Ibid., p. 266; *Scientific Progress*, p. 80. Cf. also the treatment of Putnam on pp. 47–48 of *this volume.*

ceptual perspective) may be considered to involve the application of a certain concept (rabbit) to it."[15]

This remark by Gómez is an instance of a form of comment on my work that often recurs and which is ill-founded, namely that of taking me to be making a factual claim when I am presenting a theory,[16] and suggests that those making such comments are unaware of the difference. Presenting a theory, as I see it, involves stipulating certain things regarding the categories or concepts used in the theory, in order to indicate more precisely what they are, which at the same time should give the theory structure. In the present case, what I am doing is *suggesting* that to perceive something e.g. as a rabbit may be considered to involve the application of a certain concept to the thing (independently of whether I believe it does or not). This suggestion is part of the presentation the Gestalt Model, which, in *Scientific Progress*, is itself part of the presentation of the Perspectivist conception of science.

### *Identification of the Intended Domain*

A number of reviewers have had difficulty with my notion of an intended domain. Andersen, for example, suggests that my *claim* that "differing conceptual perspectives can have the same reference" requires a theory of reference;[17] Oderberg wonders how the scientist is to *know* what it is his theory is supposed (by him) to apply to (!?);[18] and Gómez demands a better account of how the intended domain is identified.[19]

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[15] Gómez (1992), p. 267.

[16] Gómez makes the same sort of mistake earlier in his review when he says that I *believe* that each intended domain is neutral with respect to the particular views under consideration. Similarly, Andersen takes me to be *claiming* that differing conceptual perspectives can have the same reference (1997, p. 266), while Oderberg takes me to be stating as a matter of fact that that to which a model is applied is determined by the intention of the individual applying it (1997, p. 193), when in all of these cases what I am doing is presenting part of my theory. In this regard see also *this volume*, p. 165, n. 30.

[17] Andersen (1997), p. 266 – see also previous note; *Scientific Progress*, p. 80.

[18] Oderberg (1997), p. 193.

[19] Gómez (1992), p. 267.

I believe, however, that I have made it quite clear in *Scientific Progress* what the intended domain of a perspective is, and how it is to be determined – both from a subjective or first-person and from an objective or third-person point of view; and I believe further that the problem these writers find with my clarification is not because it is flawed or incomplete, but because their inability to relinquish the logico-analytic conception of reference has prevented them from understanding it.

The core of the clarification of the nature of the intended domain and how it is to be determined on the Perspectivist conception is as follows:

> [W]e should say that when a scientist moves from one of two incommensurable theories to the other, he can still very well *intend* that both theories apply to the same states of affairs, even if they characterise those states of affairs in essentially different ways. Furthermore, on the basis of certain criteria (such as the performance of the same sorts of operations), we, as onlookers, can often judge that the scientist is treating of one and the same aspect of reality in his respective applications of the two incommensurable theories.[20]

Here we have a characterisation from a *subjective* point of view: the intended domain is determined by the *intention* of the theorist (if *he* doesn't determine what he's applying his theory to, who or what does?). And we have a characterisation from an *objective* point of view: given that we are not in the position simply to *ask*, our criteria for determining e.g. whether two theories have the same intended domain depend on such intersubjective criteria as the nature of the operations involved in their respective applications.

At various points I specify what I mean in greater detail. For example I link the notion to the Gestalt Model:

> [D]iffering conceptual perspectives can have the same *reference.* The use of this term is to suggest the idea that a conceptual perspective, in being an applied concept or system of concepts, in a sense 'points' in a certain direction. And the direction in which it 'points' is in turn dependent upon the *intention* of the person applying the concept or conceptual framework, and not on the concept itself. Thus, as has been suggested in the previous chap-

[20] *Scientific Progress*, p. 79; next quote, p. 80.

ter, the 'duck' and 'rabbit' concepts of the Gestalt Model might each be intended to apply to a different figure, and consequently be said to be given different references.

And I provide an example from science in explicating the kinetic theory of gases:

> [T]he intended domain of a scientific theory is to be thought of as encompassing all of the empirical states of affairs to which it is intended that its model be applied. Thus we see that the reference given van der Waals' model is broader than that given the ideal gas model, in that it is intended to be applied not only to substances in their purely gaseous form, but also to such substances when they undergo a change of state.[21]

Of course one can attempt to apply the notion to more cases, and perhaps develop it further, but as regards the philosophical question of what I mean by the intended domain of a theory and how it is to be delineated, it would seem to me that what I have provided should suffice.

### *Categories and Perspectival Incompatibility*

On the Perspectivist conception, if scientific theories involve the application of different predicates from the same category to the same intended domain (at the same logical time), then they should be *perspectivally incompatible.*[22] Perspectival incompatibility is to be independent of whether the competing perspectives suggest the same or different results. This idea is clearly exemplified in the Gestalt Model in the form of the cube gestalt-switch (the Necker cube): you can see the cube as though you were looking at it from either above or below, but the differences of perspective are not manifest empirically. Though such clear exemplifications may be more difficult to find in the context of science, the Tychonic and Copernican conceptions of the solar system constitute an instance of where two models conflict even though they suggest the same results.[23]

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[21] Ibid., p. 95.
[22] Cf. ibid., p. 84.
[23] Other examples include the Machian vs. Newtonian conceptions of space (ibid., p. 200), the eccentric vs. epicycle hypotheses regarding the motions of the planets (see Heath, 1913, p. 266), and a thought-experiment involving perfectly circular

More than this, however, it is also suggested in *Scientific Progress* that in at least one area in physics (gas theory) the categories – space, time, mass, and so on – involved in different perspectives are *quantified.* Such quantified categories I call *parameters.* In the case of parameters, the predicates or concepts falling under them are rational number *values*; and perspectival incompatibility should arise between gas theories only if they respectively involve the application of the same parameter(s) but with different values.[24]

In this regard Andersen raises an interesting point:

> But if theories conflict only if they involve different concepts from the same category, and different concepts are understood by the 'quantified categories' view as different values, then theories can only conflict if they involve the same parameter but predict different values.[25]

I believe the key to meeting Andersen's point may lie in the distinction I draw in *Scientific Progress* between parameters quite generally and *measurable* parameters,[26] a distinction I develop further in the present volume. In this development I call measurable parameters *magnitudes*, suggesting that "theoretical laws may be expressed by equations; and while such equations must depict relations between quantities, given the hypothetical nature of theoretical models they need not depict relations between magnitudes."[27] Thus there can exist quantitative differences on the theoretical level without those differences being manifest in what is measurable on the empirical level.

We see a similar difference between mensural and non-mensural levels in the Tycho/Copernicus case. Though all the categories in the two models are (potentially) quantitative, the differences between

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orbits about the sun, in the one case their being conceived of as due to a gravitational attraction, and in the other as due to circular motion being natural (*à la* Aristotle).

[24] Cf. *Scientific Progress*, pp. 89 and 97.

[25] Andersen (1997), p. 267.

[26] *Scientific Progress*, p. 98.

[27] *This volume*, p. 114; I also say that, "due to the possible inaccessibility of theoretical mechanisms, some of the properties represented in the theoretical equations, while being quantities, may not be magnitudes." (p. 116). As regards the hypothetical nature of theories, cf. ibid., esp. Chapter 4, Section 4.

the two views – their different conceptions of the motion and rest of the sun and the earth – are nevertheless not *measurable*, and thus cannot be manifest in their results. In this case the difference concerns the category of space, the one perspective taking the earth to be motionless in space and the other taking the sun to be so. But this difference, while physically conceivable, has no influence on the empirical level since space itself cannot here be quantified in such a way as to link it to a relevant magnitude. While space is quantifiable in certain mensural respects – as regards distance etc. – in the present example it is not quantifiable with regard to absolute motion, and so the perspectival incompatibility is not manifest on the empirical level.

What in this regard is important about my notion of perspectival incompatibility, however, is that it suggests that the essence of theory conflict lies in the conceptual cores of the theories, and not in whatever empirical results as may be derived from them. Competing theories constitute mutually exclusive ways of conceiving of reality which conflict with each other as *wholes*. Nevertheless, it is not to be denied that Andersen's comment points to certain aspects of the Perspectivist conception that might be further developed. Such a development could involve, for example, considering whether *all* categories expressed in *all* physical theories *must* be quantifiable (and if so, why), whether some category or categories (e.g. that of cause) are different than others in this or related respects, and under exactly which conditions differences of category on the theoretical level should or should not lead to different empirical results.

## 3. PRINCIPLES

Moving on to the present book, its point, as expressed in its subtitle, is to provide an *account* of *modern science* in terms of three basic notions, namely *principles*, *laws* and *theories*. Its point is *not* to account for the fundamental principles of modern science and their history, as Andersen takes it to be.[28] Nor is it correct to say, as

[28] Andersen (1997), p. 268.

F. Weinert does,[29] that I see the major value of the book to lie in my *analysis* of such principles, the implication being that I simply assume everyone to take them to exist and to be the ones I indicate. Though I do analyse these principles, they are the principles that *I* suggest to lie at the core of science, and my analysis is of interest only to the extent that it helps demonstrate how modern science as a whole can be understood in terms of them.

Principles are however the most important of the three basic notions, since in the book the whole of science is taken to presuppose them. And the actual principles from which science is to emanate are specified, just as Kant and Whewell each specified what they took the fundamental principles of science to be.[30]

After Chapter 1, reference is made to work in the philosophy of science only when this work can help clarify the nature of science, or when it anticipates some aspect of the view I am presenting. In any case, there is a shift from dealing with a problem in the philosophy of science in *Scientific Progress*, to dealing with the nature of science itself in this volume.

Something the two books have in common, however, is that the content of each may in fact be broader than just to cover modern science. The Perspectivist conception of *Scientific Progress*, particularly as applied through the Gestalt Model, has a potentially much wider application than just to theory change in modern science,[31] as does the Gestalt Model, which, for example, I have applied by itself to the issue of identity and reference in the philosophy of language.[32] And, as far as the present book is concerned, the principles dealt

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[29] Weinert (1997), p. 330.

[30] In Kant (1786) and Whewell (1847), respectively.

[31] As regards modern science itself, one can also imagine acquiring insight into e.g. shifts between systems of co-ordinates in relativity theory, and the particle/wave dualism of quantum mechanics, by analysing them in terms of the Gestalt Model and/or the Perspectivist conception. Moving beyond modern science, "there is no reason why we could not in a different setting consider, for example, such geometrical theories as those of Euclid, Lobachewsky, and Riemann each to constitute a conceptual perspective being applied to geometrical space." (*Scientific Progress*, p. 69). The Perspectivist conception was also applied, for example, to the issue of *sustainable development* in Appendix VI of the third edition of *Scientific Progress.*

[32] In my (1986).

with in it might, in their more abstract form, be much more universal, such that perhaps all epistemological endeavours could profitably be analysed in terms of them.[33]

To succeed in providing a general philosophical account of modern science requires, among other things, showing how the central notions in the account are manifest in central aspects of science, and thereby indicating why those aspects are related to one another in the particular way that they are. The central notions in the present account being those of principles, laws and theories, the explanation includes showing in detail how, for example, in modern science empirical *laws* are explained by *theories*, which perform this function by indicating how the laws are nothing other than particular manifestations of the *principles.*

With regard to these distinctions, Louk Fleischhacker contributes some interesting thoughts:

> The starting point of this account is the observation that three levels of thought can be distinguished within science: that concerned with (empirical) *laws*, that concerned with (originally speculative) *theories*, and that concerned with (metaphysical) *principles.* If one were to take these modes of thinking independently of one another, each might lead to its own conception of science. The first would tend towards empiricism, the second towards realism, and the third towards rationalism. Dilworth, however, sees them as an integrated whole, in which thought concerning principles determines the nature of thought regarding laws and theories.[34]

### *The Principles of Science are* Relatively *A Priori*

Perhaps the two most important features of principles with respect to how they are conceived in the present volume and how they have been conceived in the past is that here they constitute the *core* of the scientific enterprise, i.e. together they function as a *paradigm*; and, as is related to this, they are merely *assumed* for the purposes of doing science, and are not taken as being *known* to be true.[35] As

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[33] In this regard, see the preceding appendix and Dilworth (2004).

[34] Fleischhacker (2002), p. 324.

[35] These aspects of the present approach are very important in distinguishing it from other approaches such as those of Kant and Whewell, where the a priori underpinnings are to constitute an absolute foundation.

noted by Chris Eliasmith,[36] this means, among other things, that they are not conceived of as necessary truths, nor as axioms from which other true statements can be formally deduced, but are rather conceptions that are subject to revision.

Oderberg raises an interesting question with regard to principles when he asks: "Are the principles 'adopted,' or are they *there*, whether or not scientists recognize their reliance on them?" This question has rather general implications concerning the doing of philosophy. The principles are adopted, but probably not consciously. Nor can they be said to *exist* in any real sense even when they are unconsciously adopted, other than perhaps in the backs of the minds of those adopting them. From one point of view they are nothing other than the referents of a particular abstract conceptual scheme applied to the situation after the fact in order to make as much sense of it as possible.[37]

Alexander Bird, for his part, wants to know what the fundamental principles of modern science explain.[38] But principles do not explain anything; they constitute the core from which explanations emanate; they are what is *presupposed* in any explanation. Bird further suggests that the fact that modern science presupposes the uniformity principle does little to characterise the enterprise, except to the extent that if scientists did *not* presuppose it, they would not bother going to work. Apart from the fact that, as I show in detail in Chapter 3, the whole of the empirical aspect of science rests on the principle, even if the characterisation of its effects were limited to suggesting that without it scientists would not bother going to work, this in itself would constitute important information concerning the nature of science.

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[36] Eliasmith (1998), p. 657; quote following, Oderberg (1997), p. 193.

[37] Cf. *this volume*, p. 71–72; it may be of some interest to note that this line of thought also applies to the Deductive Model. In the present volume what are being referred to as ontological principles are *conceptual*; the distinction between conceptual principles and their potential correspondents in reality (*real* principles) is taken up in my book *Simplicity*, presently in preparation.

[38] Bird (1997), p. 285.

## *The Primacy of Ontological as versus Methodological Principles*

In this book the thesis is presented that the nature of science can be better understood by taking it to be based on particular *ontological* principles than in any other way, including taking it to be based on particular *methodological* principles (such as those of verifiability or falsifiability). In this regard Joel Katzav suggests that:

> many philosophers who hold that it is method which defines science would not . . . wish to deny that in general the theories of modern science have been formulated with something akin to the metaphysical principles Dilworth spells out in mind.[39]

In response to this I should first say that, as regards the question of defining science in terms of method, as I have demonstrated elsewhere, efforts to do so have been quite unsuccessful.[40] The next question concerns how best to *explain* science, so if 'methodologists' were to accept my explanation in terms of ontological principles this would only be to the good, particularly considering that they themselves have been unable to explain science in terms of method. However, if we grant, as Katzav suggests, that 'methodologists' would accept something similar to the ontological principles I indicate, it may then be asked with what right they should do so. What is it in their methodological principles, whether they be of verifiability or falsifiability or whatever, that should allow them to say, e.g., that some form of the principle of the uniformity of nature holds for physical reality as conceived in science? As implied by Hume's arguments concerning induction, the view that reality is uniform demands an act of faith. In other words it demands the acceptance of a particular ontological configuration *before* the methodology is put into effect.

Katzav says further that,

> if the metaphysical principles used by a community were to differ radically enough from those of modern science, Dilworth would not apply the term modern science to describe the practices of that community, whereas those

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39 Katzav (1997), p. 316; next quote, ibid.
40 In this regard see *this volume*, p. 241&n.

who take method to characterise modern science might still wish to do so. However, this difference is merely a matter of definition, and not a dispute over matters of fact.

This strikes me as a very strange thing to say. Philosophical disputes are never over matters of fact; and such "matters of definition" as Katzav refers to determine how we conceive of reality. The question of whether it is better to conceive of modern science as based on ontological or methodological principles should be of central importance to the philosophy of science. On Katzav's way of thinking, *any* result obtained in the philosophy of science ought to be classed as 'merely a matter of definition.' Regarding the distinction between science and non-science in particular, great emphasis has been laid in the academic world at large on the attaining of scientific status. The whole thrust of the empiricist and Popperian methodologies, with their respective distinctions between science and pseudo-science, was to indicate what should and should not be considered to be a scientific form of investigation. If one philosophical approach says that a certain form of inquiry is (modern-)scientific while another does not, the matter is certainly of greater importance than simply to be termed one of definition.

## *Refined Principles*

*Principles* are of two sorts, *fundamental*, which constitute the core of the whole of science, and *refined*, which are derived from the fundamental principles, and, among other things, define various scientific disciplines.

Hanne Andersen suggests that the relation between fundamental principles and refined principles could be made clearer.[41] Here I shall attempt to do this in the case of the principle of causality and Newton's first law.

Newton's first law says that a body will continue in its state of rest or non-accelerated rectilinear motion unless acted upon by a force. The principle of causality says that change is caused. What is the relation between these two locutions?

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[41] Andersen (1997), p. 269.

Following Whewell,[42] in this book the notion of *force* in Newton's laws is taken to be the expression of the more universal notion of *cause*: force is a *type* of cause; and *change of state* is the expression of the more universal notion of *change*: change of state is a *type* of change.[43]

From one point of view, the first law is a *definition* of "cause" and "change" *for Newtonian mechanics*, where *cause* is defined as *force*, and *change* is defined as *change of state. Given* these 'definitions,' in the context of Newtonian mechanics the first law and the principle of causality are *identical.*

Note that in this way the application of Newton's first law is restricted to the bodies to which Newton's mechanics applies, whereas the principle of causality is not. The notion of physical force is a particular instance of the notion of cause, and not the other way round. In this way Newton's first law is *derived* or *drawn* from the principle of causality.[44] It indicates a particular domain in which the principle is to hold, and is thus also a *specification* of the principle.

The question of the extent to which Newton's laws ought to be considered either empirical or a priori is taken up by Weinert. He suggests that on my characterisation of empirical laws at least New-

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[42] Cf. *this volume*, pp. 11, 29n., 62n. and 64n. With reference to Newton's first law and the principle of causality in particular, Whewell says: "If we call to mind the axioms which we formerly stated, as containing the most important conditions involved in the idea of Cause, it will be seen that our conviction in this case depends upon the first axiom of Causation, that nothing can happen without a cause. Every change in the velocity of the moving body must have a cause; and if the change can, in any manner, be referred to the presence of other bodies, these are said to exert *force* upon the moving body: and the conception of force is thus evolved from the general idea of cause. *Force is any cause which has motion, or change of motion, for its effect.*" (1847), Part 1, p. 217.

Newton himself implies that force is a species of cause, where he says that "[t]he causes by which true and relative motions are distinguished . . . are the forces impressed upon bodies to generate motion" (1687, p. 10); and among modern writers it is taken for granted e.g. by Ellis in his (1965): cf. esp. pp. 39–40, 47 and 53–54.

[43] Cf. *this volume*, p. 64: "[C]hange consists in change of state (rather than change of position) due to the presupposition of the substantiality of motion."

[44] Cf. ibid., p. 62: "[S]uch refinement does not consist in the refined principles' being formally *deduced* from the more fundamental principles, but rather in their being *drawn* from them in such a way as to allow the fundamental principles to be *applied* in particular cases."

ton's second and third laws ought to be considered empirical, while I claim that Newton's laws ought to be seen as being principles.[45] The point is, however, as I say in the book, "these roles do not exclude one another, and so such questions as to whether principles function in one of the ways treated here rather than another do not arise." And in this general regard I point out a weakness in the logico-linguistic approach: "many questions in analytic philosophy concern the status of particular expressions without at all considering that they can have a different status in different contexts."[46] Refined principles can and do function in different ways in different contexts.[47] In fact part of the very refining of fundamental metaphysical principles consists in making them applicable to reality,[48] in the case of modern empirical science, ultimately to mensural reality.

## 4. REALISM VS. EMPIRICISM

In the introductory chapter of this book the historical debate over empiricism and realism in the philosophy of science is presented. This is done in order to afford a detailed depiction of a topical, complex issue in the philosophy of science so as subsequently to be able to show how it can be handled by my metaphysics of science. The content of the book itself stands above such issues. As I say in the chapter on principles, "[no] prescriptive stance [is] being assumed with regard to the empiricism/realism debate. ... Rather, the main aim of the present work is to capture the essence of modern science,

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[45] Weinert (1997), p. 331; *this volume*, p. 65. Quote following, ibid., pp. 65–66.
[46] Ibid., p. 66, n. 29. In this regard, cf. also my remarks concerning 'context-blindness' in Dilworth (1992), pp. 207–210.
[47] In this regard cf. *Scientific Progress*, p. 134: "The question often arises in considerations of Newton's theory as to whether his axioms or laws of motion ought best to be taken as definitions (or a priori truths), or as empirical laws, and the conclusion usually drawn is that they can function in both sorts of ways. This conclusion ... is easily accommodated on the present view."

As expressed by Ellis: "Newton's second law of motion thus has a variety of different roles. ... To suppose that [it] must have a unique role that we can describe generally and call the [epistemo]logical status is an unfounded and unjustifiable supposition." (1965, p. 61). In this regard cf. also Hanson (1958), pp. 97ff.
[48] Cf. n. 44 above.

and in so doing indicate the positions of empiricism and realism with regard to it."[49] As it turns out, my metaphysics of science vindicates realism at the expense of empiricism. But things could have been the other way round, such that it favoured empiricism over realism. What is important is that the metaphysics presented in the book can *resolve* this issue; that it shows one or the other of these views to be more in keeping with the nature of modern science is incidental. Some of my reviewers have appreciated this fact, and others have not.

Ian Hinckfuss grasps the idea where he says:

> Dilworth aims to give a description of modern science and use it to resolve the main philosophical issues in the philosophy of science, including the problem of induction, the nature of scientific reduction, the problem of natural kinds, and the debate between what he calls 'empiricism' and 'realism.'[50]

And Weinert also appreciates it:

> Dilworth attempts to show how the principles are related to the other two pillars of science, laws and theories. In the process of clarifying these relationships, Dilworth also hopes to shed light on the empiricism/realism debate in current philosophy of science.

Some other authors, however, have misunderstood my intentions, and have taken me be a realist,[51] or to be presupposing,[52] defending,[53] or arguing for[54] realism. These reviewers are working on a level where the empiricism-realism question is as deep as it gets. This is how the majority of modern commentators deal with the issue, not realising that in most cases they are at the same time presupposing an empiricist conception of science.

With regard to my treatment of this issue, Eliasmith suggests that my choice of principles stacks the deck in favour of realism: "Hav-

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[49] *This volume*, p. 52. It may be noted that I do not presuppose or defend either empiricism or realism in *Scientific Progress* either. There I say, for example, that "the Perspectivist view may be seen to be in keeping with both realist and instrumentalist conceptions of scientific theory." (p. 166, first three editions).
[50] Hinckfuss (1998), p. 130; next quote, Weinert (1997), p. 331.
[51] Bird (1997), 284.
[52] Eliasmith (1998), p. 658.
[53] Oderberg (1997), p. 193.
[54] Katzav (1997), p. 316; quote following, Eliasmith (1998), p. 658.

ing built a realist position into these core principles of science, it is hardly surprising that Dilworth determines that science is a realist project." But what is key here is that my metaphysics of science can handle all of the central aspects of science, including the role played by theories (thereby e.g. solving the problem of theoretical terms), as well as function in other ways as well, such as by affording a framework for the comparison of modern science with other epistemological activities, as in the previous appendix. If Eliasmith believes some other choice of principles could do this and at the same time vindicate *empiricism*, then he should indicate just what those principles are, and how they accomplish that end.

Katzav, while he on the one hand sees me as arguing for realism, nevertheless captures the spirit of what I am suggesting where he says:

> Knowledge of empirical laws and the attempt to gain understanding by explaining them are . . . the two basic aims of science. Moreover, it is these aims that give science its realist flavour. Conceived of as above, science is [realist] in the sense that (1) the empirical laws relate quantities and these are not directly observable, and (2) making sense of facts involves conceiving of a particular ontology which *might* ground them. Indeed . . . not only is science [realist] but also it *ought* to be so, since the attempt to gain understanding via the principles of science is essential to the scientific enterprise.[55]

## 5. UNDERSTANDING VS. KNOWLEDGE

I considered the separation of scientific *knowledge* from scientific *understanding* to be very important already in *Scientific Progress*;[56] and the results of my investigations in preparing the present volume only strengthened this conviction. As noted by Eliasmith, on the view advanced in this volume, "Laws provide scientific *knowledge* (and are [conceptually] prior to theories), whereas theories, by linking laws to principles, provide scientific *understanding.*"[57]

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[55] Katzav (1997), p. 315.
[56] Cf. *Scientific Progress*, pp. 174, 182–183 and 207.
[57] Eliasmith (1998), p. 657.

I go on in this volume to indicate how the understanding provided by theories need not be a *correct* understanding.[58] When theories are first put forward they are only hypothetical, and thus so is the understanding they afford. This of course is not to say that they may not sooner or later be determined to be essentially correct (or mistaken), in which case we can then speak of them as providing a correct (or faulty) understanding. Part of this idea is captured by Katzav, where he says:

> Dilworth, it should be noted, leaves open the question of whether we can actually have knowledge of the entities referred to by scientific explanations. [T]he attainment of understanding, one of the two central aims of science, does not require the attainment of knowledge of a transcendent realm.[59]

Thus, I find it difficult to understand Hinckfuss' saying: "Dilworth correctly draws a distinction between knowledge and understanding, but fails to allow that understanding may be a sub-species of knowledge." Considering that I go to great lengths to indicate how understanding *differs* from knowledge, including that it can be mistaken while knowledge cannot, this comment seems quite out of place.

## 6. THE PTL MODEL OF SCIENTIFIC EXPLANATION

The determination of the nature of scientific explanation must be a central aspect of any philosophy of science in which the notion is admitted. In this book I devote the whole of Chapter 5 to this question, where I present the Principle-Theory-Law (PTL) model of explanation. This conception is rather well described by Bird:

> The job of the [theoretical] scientist is to explain [empirical laws], that is, to show how they are manifestations of the discipline's basic principles. This is what is achieved by the theoretical model. One instance might be the following. Boyle's law is an empirical law – an observed regularity. The principles of our discipline are Newton's laws of motion. Our theoretical model has a 'substantial' element – the ontological bit which tells us what sorts of stuff

[58] *This volume*, p. 105.
[59] Katzav (1997), p. 315; next quote, Hinckfuss, p. 132.

we are dealing with, molecules in this case. It employs the [refined] principles, Newton's laws, working on the substance, the molecules, and by relating magnitudes at the theoretical level with those at the observable level, e.g. mean kinetic energy and temperature, it is able to derive the empirical law.[60]

One criticism of the PTL model is that of Weinert, who says:

> [I]t is hard to see why the subsumption of a particular fact or a regularity under a fundamental principle should be an explanation of the fact or the regularity. . . . To be told that Snell's law or Ohm's law are but manifestations of the principle of uniformity is not to be told why Snell's or Ohm's law take their particular form.

Weinert appears to be missing a few of points here. First, as I noted in response to Bird above (p. 283), the role of principles is not to explain, but to constitute the basis or core from which explanations are made; that empirical laws are the manifestation of the uniformity principle is *presupposed.* Second, their *explanation* consists in showing *how* each results from the operation of the principle of *causality*, normally mediated by the principle of *substance.* Third, as should be impossible to miss due to the very name of the Principle-Theory-Law model, such an explanation requires the construction of a *theory* in which the principles are clearly manifest and from which the laws in question can be derived. With regard to Weinert's example, it is not the uniformity principle that indicates why Snell's law and Ohm's law take the particular form that they do, but Maxwell's electrodynamic *theory.*

Weinert goes on to suggest that "the PTL model is still a subsumption account of explanation, but one in which the appeal to causal laws and mechanisms is of primary importance."[61] As regards the latter point, what is of primary importance are the principles being presupposed in the explanation; it is the principles which may or may not lead to the conceptions of causal laws and mechanisms. The existence of such entities is not being *appealed to*, but *explained* – a point to which I shall return below.

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[60] Bird (1997), p. 285; next quote Weinert (1997), p. 333.
[61] Ibid.; next quote, Hinckfuss (1998), p. 131.

But as regards the first point, that the PTL model provides a subsumption account of explanation, while it may be true, it leads one to think that the account I provide involves the idea of *formal* subsumption, which it does not. Ian Hinckfuss goes further in this direction when he says:

> The PTL model is supposed to explain how the theories explain how the empirical laws are a manifestation of the refined principles. Presumably they would do this only if the empirical laws were deducible from the principles and theories. [This] is in line with the D-N model.

What these authors apparently fail to realise is that no matter what model of scientific explanation one employs, what is explaining must, *in some sense*, subsume what is being explained.[62] This subsumption takes the form of logical deduction on the D-N model, but not on the PTL model. I have used the term "derivation" in this respect, and have shown in detail in Section 3 of Chapter 5 how it works – which is in a way that is clearly different from that of formal subsumption.

What is key here, however, is how the D-N and PTL models are expressions of fundamentally different ways of conceiving of science. The PTL model is the expression of how explanation is to be understood according to a particular conception of modern science which sees the enterprise as emanating from three particular ontological principles, with the principles being indicated. The D-N model, on the other hand, is essentially an expression of the view presented in Aristotle's logic (as developed by the Stoics), which the contents of this book (and of *Scientific Progress*) should show clearly to be conceptually far distant from the phenomenon of modern science (as it is from Aristotelian science, for that matter). It would appear that both Hinckfuss and Weinert are merely trying to understand my view in terms of their own logical-empiricist paradigm.

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[62] As I say in another context, i.e. with regard to the Perspectivist conception, where the subsumption in question is also not formal: "in some sense, succeeding theories do subsume their rivals," and "[t]hough there is a sense in which the rabbit aspect both is superior to and subsumes the duck aspect, this superiority does not rest in the latter's being formally deducible from, or reducible to, the former." (*Scientific Progress*, pp. 49, 65).

### *Causal Mechanisms*

Similarly to the claim that I am a realist, it has also been suggested that I *rely* on the notion of causal mechanisms, and that I am *endorsing* a causal conception of scientific explanation.[63] In reply I might begin by asking what it is that I am "relying on the notion of causal mechanisms" in order to do. I am certainly not relying on it in order to present my metaphysics of science. In fact I am not relying on it for anything. I am *explaining* why the notion is so important in modern science (as is apparent, for example, from the views of various non-committed commentators cited in Appendix II). What I am *relying on* in the present work is that the three conceptual principles I take to be at the heart of science actually are so. Given that they are, one's thinking is led to a conception of science in which the role of what are generally admitted to be causal mechanisms in science becomes clear. That there exist theories representing causal mechanisms is a *result* of the effect of the principles of modern science on the discipline as a whole. And what I am *endorsing* is not a causal conception of scientific explanation, but rather a particular way of seeing science, which is such that the commonly accepted idea that science attempts to provide causal explanations is both explained and shown to be correct.

## 7. QUANTUM MECHANICS

The idea that the principles of science are *relatively* a priori, as advanced in this book, is a new way of looking at the relation between (conceptual) principles and the epistemological enterprise (in this case, modern science) for which they are the principles. As mentioned above (p. 282), the relativity of the principles of science takes the form both of their constituting the *core* and not the *basis* of science, and in their being emendable given the results of scientific inquiry itself.

With regard to quantum mechanics in this context, Weinert says:

[Dilworth] affirms that revolutionary changes in 20th century science like

[63] Weinert (1997), p. 332.

relativity theory, quantum mechanics and chaos theory involve an alteration of epistemological principles rather than of ontological principles. These changes, he continues, do not involve ontological insights. The literature on the philosophy of quantum mechanics, at least, says otherwise. The Bell inequalities show that such fundamental classical notions as locality have no place in ontological interpretations of the quantum world. The quantum world seems to require a non-classical ontology.[64]

First, it should be pointed out that on my metaphysics of science chaos theory is not a part of modern science;[65] and second, that Weinert is mistaken in saying that I hold that revolutionary changes in twentieth century science involve an alteration of epistemological principles rather than of ontological principles. Regarding this latter point, I explicitly say on the contrary that: "Since the turn of the twentieth century however, the [ontological] principles of modern science in its core discipline of physics have come to be qualified in ever more drastic ways."[66] But I also say that when it comes to change of principles, the change is more radical when seen from an empiricist than from a realist point of view.[67] In other words, empiricists are more inclined than realists to see epistemological states of affairs, such as the inability to *detect* a causal link, or the inability to *determine* the simultaneous position and velocity of a particle, as implying that there *is* no causal link and that particles *as a matter of fact* do not have both a position and a velocity at the same time, while realists, on the other hand, are more inclined to leave such questions open, or to investigate the situation further.

Rather generally when it comes to the core principles of a discipline and their emendation, I suggest that even when an emendation

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64 Ibid., p. 334.
65 *This volume*, pp. 189–190.
66 Ibid., p. 130. Cf. also pp. 107, 205, and 69: "if . . . every possible way of theoretically reconciling the phenomena with the ontological principles in question appears blocked, the principles may themselves come to be questioned, and eventually be emended or perhaps even replaced."
67 Ibid., p. 188. Cf. also p. 176, n. 6: "One here sees how the propensity interpretation is positivistic or empiricist in its orientation, since it takes limitations on the acquiring of empirical knowledge as being a direct indication of a characteristic of the world being investigated. Here, as elsewhere, the ontological collapses into the epistemological on the empiricist view."

has been generally accepted, it is not that the core principle in question has been discarded; rather, it has been *shelved.*[68] And, equally important, the categories in terms of which it has been framed are retained.[69]

Evidence suggesting the need to alter a particular principle in a scientific discipline is originally considered with scepticism. In the beginning it constitutes a Kuhnian puzzle; and if it persists it becomes a *problem* which, if it cannot be solved given a good deal of effort, may eventually lead to an emendation of the principle. And though less attention may thereafter be devoted to the problem, the door is always left open to its eventually being solved.

We see this quite clearly in the history of science with regard to the principle of contiguity. Though no mechanism has been found for gravity or the other fundamental forces, the discovery of such a mechanism, unlike Heisenberg's uncertainty principle or the Bell inequalities, would only be welcomed. This is how the core principles function, that is, as *ideals* which, while not always met in research, nevertheless tend to set the direction of that research. That contiguity still constitutes such an ideal is clear from the fact that scientists since Newton and up to the present have constantly been seeking a medium for the transmission of gravity.[70]

That this is also the case in the realm of quantum mechanics is manifest in the great attention that has been paid to Bell's inequalities and non-locality. This attention derives from the importance of contiguity and proximity to modern-scientific thought, and the fact that non-locality not only implies an absence of contiguity, but of proximity-dependent influence as well, thus taking it even further from the ideal. Thus the core principle of contiguity is still at work in science today, while the increasing difficulties experienced in attempts to show empirical data to be in keeping with it have perhaps led to a reduction in the efforts being made to do so, and in some cases to the disappearance of such efforts altogether. Similar things may be said of Heisenberg's uncertainty principle, its having

[68] In keeping with what has been suggested on p. 181 of ibid.
[69] As suggested on p. 61 of ibid.
[70] As is in keeping with the main text, pp. 101–102, and is implied in the previous appendix, p. 245, n. 13 and accompanying text.

received so much attention being a manifestation of the fact that the deterministic form of the uniformity principle lay at the core of science; and as long as there are physicists who try to find ways round Heisenberg's results it may be said still to do so even for quantum mechanics.

Andersen suggests that in the book the question of how principles are modified is only briefly touched upon.[71] Developing this point further then, I should say that what leads to the emendation of particular principles must ultimately be the results of empirical research. The results of measurement indicate the existence of a situation that is theoretically intractable given that the theory or theories in question presuppose the original principle or principles.

*How* principles are changed can thus be said to be in such a way that the empirical evidence can be explained by a theory or theories based on the emended principle(s).[72] This move may take various forms (such as that of a 'working hypothesis') or take place in certain scientific disciplines but not in others. However, since quantum mechanics constitutes what is presently the fundamental discipline of modern science,[73] if such a change (not merely as a working hypothesis) were to occur there, its influence should penetrate the whole of science – though its effects may only be *manifest* in quantum mechanics itself, since they are too small to appear or be relevant elsewhere.

From this we may go on to note the difference between *emending* a particular principle, such as that of causality coupled with contiguity, and *exchanging* one principle for another, or *removing* a principle altogether. According to my metaphysics of science, it is only in the latter case that one may speak of a change of science (and here it is *not* merely a matter of shelving the principle in question). In this volume I have contrasted major and minor scientific revolutions, major revolutions consisting in a change in one or more principles, and minor revolutions consisting in one theory's being replaced by or developed into another.[74] Here I can clarify this situation further.

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[71] Andersen (1997), pp. 269–270.

[72] In this regard, cf. *this volume*, pp. 106–107.

[73] In keeping with the hierarchy indicated on pp. 4, 56–57 and 150 of ibid.

[74] Ibid., pp. 104 and 107.

A change of principle which is only an *emendation* of the principle vis-à-vis the core principles of science constitutes a major revolution *within* science, while a change involving an *exchange*, *addition* or *dropping* of one or more principles of science as a whole constitutes a major revolution *of* science, or what may be termed a *fundamental* revolution. Thus fundamental revolutions (or the having of essentially different principles) separate *sciences*, where major revolutions (or the having of the same fundamental principles interpreted differently) separate *disciplines within* a science. And we may therefore say that, to the extent that there has been an emendation of principles in physics with the acceptance of quantum mechanics, quantum mechanics itself constitutes a discipline different from Newtonian mechanics. But it does not constitute a different *science.*

Note how the notion of *paradigm* is to be applied here. If we accept that quantum mechanics involves an emendation of the principles of physics, though the principles of modern science have not changed (though they have been weakened), those of the discipline of mechanics have changed, and with that change quantum mechanics can be said to have a paradigm different from that of Newtonian mechanics, while the paradigm for science as a whole remains the same. And though the changes in the principles of science's central discipline of physics may have called the paradigm of science as a whole into question, it still functions as the ideal which scientific research generally tries to meet. But even if the paradigm for modern science as a whole should be emended such that e.g. strict determinism were no longer the ideal for scientific research generally, then it would still be against the background of the original deterministic ideal, and in terms of its categories, that the emendation is to be understood, and in that way the original paradigm would still be operative. However, should one or more of the principles of science as a whole be removed or replaced, then we would have a new paradigm for science, and we should no longer say that we still have to do with *modern* science.

We can see the kind of difference that would lead to this sort of change, i.e. to a *fundamental* revolution, if we consider the potential core principles of the various practices or epistemological endeavours treated in Appendix II, where causes can emanate from *spiritual* entities. A change of this sort occurred in the Scientific Revolution, where Aristotle's principle of causality, which allowed teleological and spiritual causes, was *replaced* by the modern-scientific principle of efficient contiguous physical cause.

## 8. CONCLUSION

As should be evident from the above, all of my reviewers, with the exception of Fleischhacker, have been operating from within an essentially logical-empiricist frame of reference,[75] which to my mind has made it impossible for them to properly appreciate the views being advanced in either of my books. And to this I should add that, quite possibly due to this same predisposition, they have devoted little attention to what I consider to be the books' central aspects.

As regards *Scientific Progress*, no comment is made as to whether or not my theory has succeeded in meeting Kuhn's and Feyerabend's claims while avoiding relativism, including the idea that there can exist *criteria* for judging the relative acceptability of the different aspects of gestalt-switch phenomena, which previously had always been considered to involve a purely arbitrary choice (by Feyerabend, for example). Nor, as regards that book, is there any discussion concerning non-formal conceptual conflict, a notion that is a fundamental aspect of the Perspectivist conception.

As regards the present volume, no mention is made of the central idea that modern science is only one form of science. And the question is not broached as to whether this work succeeds in avoiding the problems met by earlier aprioristic views (such as those of Kant and Whewell), according to which the fundamental principles of science were to be apodeictic rather than hypothetical and constitute the foundation rather than the core of science. Furthermore, science's presupposition of the three particular principles suggested in this book in such a way that its empirical and theoretical aspects are

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[75] As is in keeping with what I say e.g. on p. 13 of ibid.: "the view [of the Vienna Circle] has been so widely held during the twentieth century as practically to constitute the discipline of the philosophy of science itself; and its influence on those who believe themselves to have moved beyond it is still strong today." Cf. also pp. 43&n., 93 and 185&n.

made clear is nowhere mentioned. Nor, as is related to this, is the question of the importance of distinguishing between the principles of uniformity and causality taken up. Also, the idea that empirical science is empirical in a mensural and not a phenomenal way, and is thus essentially concerned with reality as it is in itself and not reality as we experience it (*pace* Kant), is nowhere discussed. And no one, except Fleischhacker, addresses the pressing social questions raised in Chapter 10.

In sum, my commentators seem unaware of when they are dealing with a philosophical *theory*, whether it be the one they themselves unconsciously adopt (based on the Deductive Model), or the alternatives I have provided in *Scientific Progress* and the present volume. In the case of my own work this is evident from the piecemeal treatment it has received, when what is required is that the views I present each be treated as a *whole.* And the many factual mistakes that have been made in commenting on my work indicate further that it must be read with much greater care. Considering the many problems faced by the theories presently being embraced in the philosophy of science, it seems to me that the views expounded in these two works deserve serious consideration *as comprehensive alternatives* – a consideration they have yet to receive.

# REFERENCES


Abernethy, V.

(1993) *Population Politics: The Choices that Shape Our Future*, N.Y.: Plenum Press/Insight Books, 1993.

Agazzi, E.

(1977) 'Subjectivity, Objectivity and Ontological Commitment in the Empirical Sciences,' *Historical and Philosophical Dimensions of Logic, Methodology and Philosophy of Science*, R. E. Butts and J. Hintikka eds., Dordrecht: D. Reidel, 1977.

(1988) 'Science and Metaphysics: Two Kinds of Knowledge,' *Epistemologia* **11**, 1988, Special Issue: 11–28.

(1992) 'Intelligibility, Understanding and Explanation in Science,' pp. 25–46 of Dilworth ed. (1992).

Alcock, J. E.

(1985) 'Parapsychology as a Spiritual Science,' pp. 537–565 of Kurtz ed. (1985).

Alexander, P.

(1963) *Sensationalism and Scientific Explanation*, London: Routledge & Kegan Paul, 1963.

Andersen, H.

(1997), Review of the third edition of *Scientific Progress* and *The Metaphysics of Science, Erkenntnis* **47**, 1997: 265–271.

Angel, L. J.

(1975) 'Paleoecology, Paleodemography and Health,' pp. 167–190 of S. Polgar ed., *Population, Ecology and Social Evolution*, The Hague: Mouton, 1975.

Aristotle

*The Complete Works of Aristotle*, J. Barnes ed., Princeton: Princeton University Press, 1984.

Bacon, F.

(1620) *Novum Organum*, P. Urbach and J. Gibson, trs. & eds., Chicago and La Salle: Open Court, 1994.

Baerreis, D.

(1980) 'North America in the Early Postglacial,' pp. 356–360 of A. Sherratt ed., *The Cambridge Encyclopedia of Archaeology*, N.Y.: Crown Publishers/Cambridge University Press, 1980.

Bailey, C.

(1928) *The Greek Atomists and Epicurus*, Oxford: Oxford University Press, 1928.

Barnowsky, A. D.

(1989) 'The Late Pleistocene Event as a Paradigm for Widespread Mammal Extinction,' pp. 235–254 of S. K. Donovan ed., *Mass Extinctions: Processes and Evidence*, N.Y.: Columbia University Press, 1989.

Bigelow, J. et al.

(1988) 'Forces,' *Philosophy of Science* **55**, 1988: 614–630.

(1992) 'The World as One of a Kind: Natural Necessity and Laws of Nature,' *British Journal for the Philosophy of Science* **43**, 1992: 371–388.

Bird, A.

(1997) Review of *The Metaphysics of Science*, *British Journal for the Philosophy of Science* **48**, 1997: 284–286.

Blackmore, J. T.

(1972) *Ernst Mach: His Work, Life and Influence*, Berkeley: University of California Press, 1972.

(1982) 'What Was Galileo's Epistemology?' *Methodology and Science* **15**, 1982: 57–85.

(1983) 'Philosophy as Part of Internal History of Science,' *Philosophy of the Social Sciences* **13**, 1983: 17–45.

Bok, B. J. et al.

(1975) 'Objections to Astronomy,' pp. 9–17 of Bok & Jerome (1975)

Bok, B. J. and Jerome, L. E.

(1975) *Objections to Astrology*, Buffalo: Prometheus Books, 1975.

Boltzmann, L.

(1899) 'On the Development of the Methods of Theoretical Physics in Recent Times,' pp. 77–100 of his (1905).

(1900, 1902) 'On the Principles of Mechanics, I, II,' pp. 129–152 of his (1905).

(1904) 'On Statistical Mechanics,' pp. 159–172 of his (1905).

(1905) *Theoretical Physics and Philosophical Problems*, Dordrecht: D. Reidel, 1974.

Born, M.

(1951) *Natural Philosophy of Cause and Chance*, Oxford: Clarendon Press, 1951.

Boserup, E.

(1965) *The Conditions of Agricultural Growth*, London: Earthscan, 1993.

Boyd, R.

(1991) 'Realism, Anti-Foundationalism and the Enthusiasm for Natural Kinds,' *Philosophical Studies* **61**, 1991: 127–148.

Braithwaite, R. B.

(1953) *Scientific Explanation*, Cambridge: Cambridge University Press, 1953.

Broad, C. D.

(1949) 'Violations of Basic Limiting Principles,' pp. 37–52 of Flew ed. (1987).

Brush, S. G.

(1968) 'Mach and Atomism,' *Synthese* **18**, 1968: 192–215.

Burnet, J.

(1914) *Greek Philosophy. Part I: Thales to Plato*, London: Macmillan, 1920.

(1920) *Early Greek Philosophy*, London: Adam & Charles Black, 1945.

Burtt, E. A.

(1924) *The Metaphysical Foundations of Modern Physical Science*, London and Henley: Routledge & Kegan Paul, 1949.

Caird, E.

(1877) *A Critical Account of the Philosophy of Kant*, Glasgow: James Maclehose, 1877.

Campbell, N. R.

(1920) *Physics: The Elements*, Cambridge: Cambridge University Press, 1920; reissued as *Foundations of Science*, N.Y.: Dover Publications, 1957.

(1921) *What Is Science*? N.Y.: Dover Publications, 1953.

(1923) *Relativity*, Cambridge: Cambridge University Press, 1923.

(1938) 'Symposium: Measurement and Its Importance for Philosophy – Part I,' pp. 121–142 of the *Proceedings of the Aristotelian Society*, Supplementary Volume XVII, 1938.

(1942) 'Dimensions and the Facts of Measurement,' *Philosophical Magazine* **33**, 7th Series, 1942: 761–771.

Čapek, M.

(1961) *The Philosophical Impact of Contemporary Physics*, Princeton: D. Van Nostrand, 1961.

Caplan, A. L.

(1981) 'Discussion: Back to Class: A Note on the Ontology of Species,' *Philosophy of Science* **48**, 1981: 130–140.

Carnap, R.

(1955) 'Statistical and Inductive Probability,' *The Structure of Scientific Thought*, E. H. Madden ed., Boston: Houghton Mifflin Co., 1960.

Cartwright, N.

(1983) *How the Laws of Physics Lie*, Oxford: Clarendon Press, 1983.

Chang, S. T.

(1976) *The Complete Book of Acupuncture*, Berkeley: Celestial Arts, 1976.

Churchland, P. M. and Hooker, C. A. eds.

(1985) *Images of Science*, Chicago: University of Chicago Press, 1985.

Clark, M. E.

(1989) *Ariadne's Thread*, N.Y.: St. Martin's Press, 1989.

Cohen, M. N.

(1977) *The Food Crisis in Prehistory*, New Haven and London: Yale University Press, 1977.

(1989), *Health and the Rise of Civilization*, New Haven and London: Yale University Press, 1989.

Comte, A.

(1830–42) *Cours de Philosophie Positive*, Paris, 1830–1842, as excerpted in *Auguste Comte and Positivism*, G. Lenzer ed., N.Y.: Harper & Row, 1975.

Crompton, J.

(1992) 'The Unity of Knowledge and Understanding in Science,' pp. 145–159 of Dilworth ed. (1992).

d'Abro, A.

(1939) *The Rise of the New Physics* (2 vols.), N.Y.: Dover Publications, 1952.

Daly, H. E.

(1992) *Steady-State Economics*, 2nd ed., London: Earthscan Publications, 1992.

Darwin, C.
(1859) *The Origin of Species*, Harmondsworth: Penguin Books, 1968.

d'Espagnat, B.
(1992) 'De l'Intelligibilité du Monde Physique,' pp. 111–121 of Dilworth ed. (1992).

Dijksterhuis, E. J.
(1959) *The Mechanization of the World Picture*, C. Dikshoorn tr., Princeton: Princeton University Press, 1986.

Dilworth, C.
(1992) 'The Linguistic Turn: Shortcut or Detour?' *Dialectica* **46**, 1992: 201–214.

(1994) 'Two Perspectives on Sustainable Development,' *Population and Environment* **15**, 1994: 441–467.

(2001) 'Simplicity,' *Epistemologia* **24**, 2001: 173–201.

(2004) 'Il senso comune, i princìpi e la scienza' ('Common Sense, Principles, and Science'), pp. 39–55 of *Valore e limiti del senso comune*, E. Agazzi ed., Milan: FrancoAngeli, 2004.

(2005) 'The Selfish Karyotype – An Analysis of the Biological Basis of Morals,' *Biology Forum* **98**, 2005: 125–154.

(2007) *Scientific Progress,* 4th ed., Dordrecht: Springer, 2007.

Dilworth, C. ed.
(1992) *Idealization IV: Intelligibility in Science*, Poznan Studies in the Philosophy of the Sciences and the Humanities, vol. 26, Amsterdam and Atlanta: Rodopi, 1992.

Divale, W.
(1972) 'Systemic Population Control in the Middle and Upper Paleolithic,' *World Archaeology* **4**, 1972: 222–243.

Duhem, P.
(1905) 'Physics of a Believer,' pp. 273–311 of the Appendix to his (1906).

(1906) *The Aim and Structure of Physical Theory*, P. P. Wiener tr., N.Y.: Atheneum, 1962.

(1908a) *To Save the Phenomena: An Essay on the Idea of Physical Theory from Plato to Galileo*, E. Doland and C. Maschler trs., Chicago and London: University of Chicago Press, 1969.

(1908b) 'The Value of Physical Theory,' pp. 312–335 of the Appendix to his (1906).

Dupré, J.

(1981) 'Natural Kinds and Biological Taxa,' *Philosophical Review* **90**, 1981: 66–90.

Edge, H. L.

(1985) 'The Problem is not Replication,' pp. 53–72 of *The Repeatability Problem in Parapsychology*, B. Shapir and L. Coly eds., N.Y.: Parapsychology Foundation, Inc., 1985.

Einstein, A.

(1948) 'Time, Space, and Gravitation,' pp. 54–58 of his *Out of My Later Years*, N.Y.: Philosophical Library, 1950.

(1949a) 'Remarks Concerning the Essays Brought Together in this Cooperative Volume,' pp. 665–688 of Schilpp ed. (1949).

(1949b) 'Autobiographical Notes,' pp. 3–95 of Schilpp ed. (1949).

Eliasmith, C.

(1998) Review of *The Metaphysics of Science*, *Dialogue* **37**, 1998: 656–658.

Ellis, B.

(1965) 'The Origin and Nature of Newton's Laws of Motion,' pp. 29–68 of *Beyond the Edge of Certainty*, R. G. Colodny ed., N.J.: Prentice Hall, 1965.

(1966) *Basic Concepts of Measurement*, Cambridge: Cambridge University Press, 1966.

(1985) 'What Science Aims to Do,' pp. 48–74 of Churchland & Hooker eds. (1985).

(1992) 'Idealization in Science,' pp. 265–282 of Dilworth ed. (1992).

Ellul, J.

(1964) *The Technological Society*, N.Y.: Random House, 1964.

Enriques, F.

(1906) *Problems of Science*, Chicago: Open Court, 1914.

(1934) *Signification de l'Histoire de la Pensée Scientifique*, Paris: Hermann & Cie, 1934.

Evans, D.

(1996) ‘Parapsychology: Merits and Limits,’ pp. 47–86 of Stoeber & Meynell eds. (1996).

Faye, J.

(1989) *The Reality of the Future*, Odense: Odense University Press, 1989.

Feyerabend, P.

(1975) *Against Method*, London: Verso, 1978.

Field, J. V.

(1987) ‘Astrology in Kepler’s Cosmology,’ pp. 143–170 of P. Curry ed., *Astrology, Science and Society*, Suffolk: Boydell Press, 1987.

Flamm, D.

(1983) ‘Ludwig Boltzmann and his Influence on Science,’ *Studies in the History and Philosophy of Science* **14**, 1983: 255–278.

Fleischhacker, L.

(1992) ‘Mathematical Abstraction, Idealisation and Intelligibility in Science,’ pp. 243–263 of Dilworth ed. (1992).

(2002) Review of *The Metaphysics of Science*, *Epistemologia* **25**, 2002: 323–327.

Flew, A.

(1987a) Introduction to Broad (1949), pp. 37–38 of Flew ed. (1987).

(1987b) ‘Introduction,’ pp. 11–20 of Flew ed. (1987).

Flew, A. ed.

(1987) *Readings in the Philosophical Problems of Parapsychology*, Buffalo: Prometheus Books, 1987.

Frankfort, F. et al.

(1946) *Before Philosophy*, Harmondsworth: Penguin Books, 1949.

Frazer, J.

(1922) *The Golden Bough: A Study in Magic and Religion*, Hertfordshire: Wordsworth Editions, 1993.

Freud, S.

(1916–17) *Introductory Lectures on Psychoanalysis*, London: Penguin Books, 1973.

Fröhlich, F.

(1959) ‘V. – Primary Qualities in Physical Explanation,’ *Mind* **68**, 1959: 209–217.

Gamow, G.

(1966) *Thirty Years That Shook Physics*, N.Y.: Dover Publications, 1985.

Georgescu-Roegen, N.

(1971) *The Entropy Law and the Economic Process*, Cambridge, Mass.: Harvard University Press, 1971.

Giedymin, J.

(1982) *Science and Convention*, Oxford: Pergamon Press, 1982.

Gingras, Y. and Schweber, S. S.

(1986) 'Constraints on Construction,' *Social Studies of Science* **16**, 1986: 327–383.

Gómez, R. J.

(1992) Review of the second edition of *Scientific Progress*, *Noûs* **XXVI**: 264–270.

Gowdy, J. M.

(1998) 'Biophysical Limits to Industrialization,' pp. 65–82 of M. N. Dobkowski and I. Wallimann eds., *The Coming Age of Scarcity*, Syracuse: Syracuse University Press, 1998.

Graves, J. C.

(1971) *The Conceptual Foundations of Contemporary Relativity Theory*, Cambridge, Mass.: MIT Press, 1971.

Griffin, D. R.

(1996) 'Why Critical Reflection on the Paranormal is So Important – and So Difficult,' pp. 87–117 of Stoeber & Meynell eds. (1996).

Guthrie, W. K. C.

(1965) *A History of Greek Philosophy. Volume II: The Presocratic Tradition from Parmenides to Democritus*, Cambridge: Cambridge University Press, 1965.

Hacking, I.

(1983) *Representing and Intervening*, Cambridge: Cambridge University Press, 1983.

(1984) 'Experimentation and Scientific Realism,' pp. 154–172 Leplin ed. (1984).

Hands, D. W.

(1985) 'Karl Popper and Economic Methodology,' *Economics and Philosophy* **1**, 1985: 83–89.

Hanson, N. R.

(1958) *Patterns of Discovery*, Cambridge: Cambridge University Press, 1958.

Harré, R.

(1967) 'Pierre Simon de Laplace,' pp. 391–393 of vol. 4 of *The Encyclopedia of Philosophy*, P. Edwards ed., N.Y. and London: Macmillan, 1972.

(1970a) 'Constraints and Restraints,' *Metaphilosophy* **I**, 1970: 279–299.

(1970b) *The Principles of Scientific Thinking*, Chicago: University of Chicago Press, 1970.

(1972) *The Philosophies of Science*, Oxford: Oxford University Press, 1972.

Harré, R. and Madden, E. H.

(1975) *Causal Powers*, Oxford: Blackwell, 1975.

Hausman, D. M. ed.

(1984) *The Philosophy of Economics*, Cambridge: Cambridge University Press, 1984.

Heath, T.

(1921) *A History of Greek Mathematics*, N.Y.: Dover Publications, 1981.

Helmholtz, H. v.

(1894) 'Preface by H. von Helmholtz,' pp. xxv-xxxviii of H. Hertz, *The Principles of Mechanics*, N.Y.: Dover Publications, 1956.

Hempel, C. G.

(1958) 'The Theoretician's Dilemma: A Study in the Logic of Theory Construction,' pp. 173–226 of his (1965).

(1962) 'Deductive-Nomological vs. Statistical Explanation,' pp. 98–169 of *Minnesota Studies in the Philosophy of Science* **III**, H. Feigl and G. Maxwell eds., Minneapolis: University of Minnesota Press, 1962.

(1965) *Aspects of Scientific Explanation*, N.Y.: Free Press, 1965.

(1970) 'On the "Standard Conception" of Scientific Theories,' pp. 142–163 of *Minnesota Studies in the Philosophy of Science* **IV**, M. Radner and S. Winokur eds., Minneapolis: University of Minnesota Press, 1970.

(1973) 'The Meaning of Theoretical Terms: A Critique of the Standard Empiricist Construal,' pp. 367–378 of Suppes et al. eds. (1973).

Hempel, C. G. and Oppenheim, P.

(1948) 'Studies in the Logic of Explanation,' pp. 245–290 of Hempel (1965).

Hesse, M. B.

(1961), *Forces and Fields: The Concept of Action at a Distance in the History of Physics*, London: Thomas Nelson and Sons Ltd., 1961.

Hinckfuss, I.

(1998) Review of *The Metaphysics of Science*, *Australasian Journal of Philosophy* **71**, 1998: 130–132.

Hotelling, H.

(1929) 'Stability in Competition,' *Economic Journal* **39**, 1929: 41–57.

Hübner, K.

(1988) 'Metaphysics and the Tree of Knowledge,' *Epistemologia* **11**, 1988: 105–120.

Hull, D. L.

(1981) 'Discussion: Kitts and Kitts and Caplan on Species,' *Philosophy of Science* **48**, 1981: 141–152.

Hutten, E. H.

(1954) 'The Rôle of Models in Physics,' *British Journal for the Philosophy of Science* **4**, 1953–54: 284–301.

(1956) *The Language of Modern Physics*, London: George Allen & Unwin, 1956.

(1962) *The Origins of Science*, London: George Allen & Unwin, 1962.

Hyman, R.

(1985) 'A Critical Historical Overview of Parapsychology,' pp. 3–96 of Kurtz ed. (1985).

Jammer, M.

(1954) *Concepts of Space*, Cambridge, Mass.: Harvard University Press, 1954.

Jerome, L. E.

(1975) 'Astrology: Magic or Science?' pp. 37–62 of Bok & Jerome (1975).

Jevons, W. S.

(1887) *The Principles of Science*, London and N.Y.: Macmillan and Co., 1887.

Johansen, L.

(1979) 'The Bargaining Society and the Inefficiency of Bargaining,' *Kyklos* **32**, 1979: 497–522.

Kahn, C. H.

(1960) 'Anaximander's Fragment: The Universe Governed by Law,' pp. 99–117 of P. D. Mourelatos ed., *The Pre-Socratics*, Princeton: Princeton University Press, 1993.

Kant, I.

(1781, 1787) *Critique of Pure Reason*, N. Kemp Smith tr., London and Basingstoke: Macmillan Press, 1933.

(1783) *Prolegomena To Any Future Metaphysics That Will Be Able To Come Forward As A Science*, P. Carus and J. W. Ellington trs., in I. Kant, *Philosophy of Material Nature*, Indianapolis: Hackett Publishing Company, 1985.

(1786) *Metaphysical Foundations of Natural Science*, J. W. Ellington tr., in I. Kant, *Philosophy of Material Nature*, Indianapolis: Hackett Publishing Company, 1985.

Katzav, J.

(1997) Review of *The Metaphysics of Science*, *Annals of Science* **54**, 1997: 315–316.

Kitcher, P.

(1984) 'Species,' *Philosophy of Science* **51**, 1984: 308–333.

Kitts, D. B. and Kitts, D. J.

(1979) 'Biological Species as Natural Kinds,' *Philosophy of Science* **46**, 1979: 613–622.

Kneale, W.

(1949) *Probability and Induction*, Oxford: Clarendon Press, 1949.

Knight, D.

(1986) *The Age of Science*, Oxford and N.Y.: Blackwell, 1988.

König, G.

(1989) 'Perspektiv,' pp. 363–377 of vol. 7 of J. Ritter and K. Gründer eds., *Historisches Wörterbuch der Philosophie*, Darmstadt and Basel: Wissenschaftliche Buchgesellshaft, 1989.

Krajewski, W.

(1977) *Correspondence Principle and Growth of Science*, Dordrecht: D. Reidel, 1977.

Kripke, S.

(1972) *Naming and Necessity*, Oxford: Basil Blackwell, 1980.

Kuhn, T. S.
(1962), *The Structure of Scientific Revolutions*, Chicago: University of Chicago Press, 1970.

Kurtz, P. ed.
(1985) *A Skeptic's Handbook of Parapsychology*, Buffalo: Prometheus Books, 1985.

Lachmann, L. M.
(1969) 'Methodological Individualism and the Market Economy,' pp. 303–311 of Hausman ed. (1984).

Laudan, L.
(1981) *Science and Hypothesis*, Dordrecht: D. Reidel, 1981.

(1984a) *Science and Values*, Berkeley: University of California Press, 1984.

(1984b) 'A Confutation of Convergent Realism,' pp. 218–249 of Leplin ed. (1984).

Lauener, H.
(1992) 'Transcendental Arguments Pragmatically Relativized: Accepted Norms (Conventions) as an *A Priori* Condition for any Form of Intelligibility,' pp. 47–71 of Dilworth ed. (1992).

Lenski, G. et al.
(1995) *Human Societies*, 7th ed., N.Y.: McGraw-Hill, 1995.

Leplin, J. ed.
(1984) *Scientific Realism*, Berkeley: University of California Press, 1984.

Lindsay, J.
(1971) *Origins of Astrology*, London: Frederick Muller, 1971.

Locke, J.
(1690) *An Essay Concerning Human Understanding*, N.Y.: Dover Publications, 1959.

Lucretius
*On the Nature of the Universe*, Harmondsworth: Penguin Books, 1951.

Mach, E.
(1883) *The Science of Mechanics*, T. J. McCormack tr., La Salle, Illinois: Open Court, 1960.

(1906) *The Analysis of Sensations*, 5th ed., C. M. Williams tr., Chicago and London: Open Court, 1914.

Machlup, F.

(1955) 'The Problem of Verification in Economics,' pp. 137–157 of his (1978); reprinted from *The Southern Economic Journal* **21**, 1955: 1–21.

(1956) 'On Indirect Verification,' pp. 198–209 of Hausman ed. (1984); reprinted from *The Southern Economic Journal* **22**, 1956: 483–493.

(1960) 'Ideal Types, Reality, and Construction,' pp. 223–265 of his (1978); translated from the original German in *Ordo* **12**, 1960.

(1961) 'Are the Social Sciences Really Inferior?,' pp. 345–367 of his (1978); reprinted from *The Southern Economic Journal* **27**, 1961: 173–184.

(1967) 'Theories of the Firm: Marginalist, Behavioral, Managerial,' *American Economic Review* **57**, 1967: 1–33.

(1978) *Methodology of Economics and Other Social Sciences*, N.Y.: Academic Press, 1978.

Mackie, J. L.

(1976) *Problems from Locke*, Oxford: Clarendon Press, 1976.

Malthus, T. R.

(1798) *An Essay on the Principle of Population*, Harmondsworth: Penguin Books, 1970.

(1830) *A Summary View of the Principle of Population*, pp. 219–272 of his (1798).

Manicas, P. T.

(1987) *A History and Philosophy of the Social Sciences*, Oxford: Blackwell, 1987.

(1992) 'Intelligibility and Idealization: Marx and Weber,' pp. 283–303 of Dilworth ed. (1992).

Martin, P. S.

(1966) 'Africa and Pleistocene Overkill,' *Nature* **212**, 1966: 339–342.

(1967) 'Prehistoric Overkill,' pp. 75–120 of Martin & Wright eds. (1967).

(1973) 'The Discovery of America,' *Science* **179**, 1973: 969–974.

(1984) 'Prehistoric Overkill: the Global Model,' pp. 354–403 of P. S. Martin and R. G. Klein eds., *Quaternary Extinctions*, Tucson: University of Arizona Press, 1984.

Martin, P. S. and Guilday, J. E.

(1967) 'A Bestiary for Pleistocene Biologists,' pp. 1–62 of Martin & Wright eds. (1967).

Martin, P. S. and Wright, H. E. eds.
(1967) *Pleistocene Extinctions: The Search for a Cause*, New Haven and London: Yale University Press, 1967.

Mauss, M.
(1950) *A General Theory of Magic*, London and Boston: Routledge & Kegan Paul, 1972.

Maxwell, J. C.
(1877) *Matter and Motion*, N.Y.: Dover Publications, 1953.

Maxwell, N.
(1984) *From Knowledge to Wisdom*, Oxford: Basil Blackwell, 1984.

McClenon, J.
(1984) *Deviant Science: The Case of Parapsychology*, Philadelphia: University of Pennsylvania Press, 1984.

McCloskey, H. J.
(1971) *John Stuart Mill: A Critical Study*, London: Macmillan, 1971.

McMichael, A. J.
(1993) *Planetary Overload: Global Environmental Change and the Health of the Human Species*, Cambridge: Cambridge University Press, 1993.

McMullin, E.
(1974) 'Empiricism at Sea,' pp. 121–132 of R. S. Cohen and M. W. Wartofsky eds., *A Portrait of Twenty-Five Years: Boston Colloquium for the Philosophy of Science 1960–1985*, Dordrecht: D. Reidel, 1985.

(1984a) 'A Case for Scientific Realism,' pp. 8–40 of Leplin ed. (1984).

(1984b) 'Two Ideals of Explanation in Natural Science,' pp. 205–220 of *Causation and Causal Theories*, P. A. French et al. eds., vol. IX of the Midwest Studies in Philosophy, Minneapolis: University of Minnesota Press, 1984.

(1987) 'Explanatory Success and the Truth of Theory,' pp. 51–73 of N. Rescher ed., *Scientific Inquiry in Philosophical Perspective*, N.Y.: University Press of America, 1987.

Mellor, D. H.
(1977) 'Natural Kinds,' *British Journal for the Philosophy of Science* **28**, 1977: 299–312.

Meynell, H.
(1996) 'On Investigation of the So-Called Paranormal,' pp. 23–45 of Stoeber & Meynell eds. (1996).

Mill, J. S.

(1881) *A System of Logic Ratiocinative and Inductive*, Books I-III, 8th ed., Toronto: University of Toronto Press, 1973.

Newton, I.

(1687) *Mathematical Principles of Natural Philosophy*, A. Motte tr., Berkeley: University of California Press, 1934.

Newton-Smith, W. H.

(1981) *Rationality in Science*, Boston: Routledge & Kegan Paul, 1981.

(1989) 'The Truth in Realism,' *Dialectica* **43**, 1989: 31–45.

Norris, C. M.

(2001) *Acupuncture: Treatment of Musculoskeletal Disorders*, Oxford: Butterworth-Heinemann, 2001.

Northrop, F. S. C.

(1931) *Science and First Principles*, Cambridge: Cambridge University Press, 1931.

Nowak, L.

(1980) *The Structure of Idealization*, Dordrecht: D. Reidel, 1980.

Oderberg, D. S.

(1997) Review of the third edition of *Scientific Progress* and *The Metaphysics of Science*, *Ratio* **39**, 1997: 188–194.

Paneth, F. A.

(1931) 'The Epistemological Status of the Chemical Concept of Element,' *British Journal for the Philosophy of Science* **13**, 1962: 1–14 and 144–160.

Paty, M.

(1992) 'L'Endoréférence d'une Science Formalisée de la Nature,' pp. 73–110 of Dilworth ed. (1992).

Plato

*The Collected Dialogues of Plato*, E. Hamilton and H. Cairns eds., Princeton: Princeton University Press, 1963.

Plutarch

*Plutarch's Moralia*, vol. XII, H. Cherniss and W. C. Helmbold trs., London: William Heinemann Ltd., 1957.

Poincaré, H.

(1902) *Science and Hypothesis*, N.Y.: Dover Publications, 1952.

(1914) *The Value of Science*, N.Y.: Dover Publications, 1958.

Ponting, C.
(1991) *A Green History of the World*, London: Sinclair-Stevenson Ltd., 1991.

Popper, K. R.
(1962) *Conjectures and Refutations*, N.Y.: Harper & Row, 1963.

Price, G.
(1955) 'Hume's Argument as a Challenge to Parapsychology,' pp. 214–226 of Flew ed. (1987).

Prichard, H. A.
(1909) *Kant's Theory of Knowledge*, Oxford: Clarendon Press, 1909.

Putnam, H.
(1984) 'What Is Realism?,' pp. 140–153 of Leplin ed. (1984).

Quine, W. v. O.
(1951) 'Two Dogmas of Empiricism,' pp. 20–46 of his *From a Logical Point of View*, N.Y.: Harper Torchbooks, 1963.

(1969) 'Natural Kinds,' pp. 114–138 of his *Ontological Relativity and Other Essays*, N.Y. and London: Columbia University Press, 1969.

Reid, T.
(1764) *An Inquiry into the Human Mind on the Principles of Common Sense*, D. R. Brookes ed., Philadelphia: Penn State Press, 1997.

Rhine, J. B.
(1954) 'The Science of Nonphysical Nature,' pp. 23–32 of Flew ed. (1987).

Robbins, L.
(1935) 'The Nature and Significance of Economic Science,' pp. 113–140 of Hausman ed. (1984).

Roberts, N.
(1989) *The Holocene: An Environmental History*, Oxford: Basil Blackwell, 1989.

Robinson, J.
(1962) *Economic Philosophy*, Harmondsworth: Penguin Books, 1976.

Robinson, R. and Broad, C. D.
(1950) 'Two Traditions on the Nature of Man,' pp. 271–276 of Flew ed. (1987).

Ruse, M.
(1976) 'The Scientific Methodology of William Whewell,' *Centaurus* **20**, 1976: 227–257.

(1987) 'Biological Species: Natural Kinds, Individuals, or What?' *British Journal for the Philosophy of Science* **38**, 1987: 225–242.

Salmon, W. C.

(1984) *Scientific Explanation and the Causal Structure of the World*, Princeton: Princeton University Press, 1984.

Samuelson, P. A.

(1972) 'Maximum Principles in Analytical Economics,' *American Economic Review* **62**, 1972: 249–262.

Schilpp, P. A. ed.

(1949) *Albert Einstein: Philosopher-Scientist*, Evanston, Illinois: The Library of Living Philosophers, 1949.

Schmalensee, R.

(1989) 'Inter-Industry Studies of Structure and Performance,' pp. 951–1009 of R. Schmalensee and R. D. Willig eds., *Handbook of Industrial Organization*, vol. II, Amsterdam: Elsevier Science Publishers B.V., 1989.

Sessions, G.

(1995) 'Preface,' pp. ix-xxviii of G. Sessions ed., *Deep Ecology for the 21st Century*, Boston and London: Shambhala, 1995.

Simon, H.

(1979) 'Rational Decision Making in Business Organizations,' *American Economic Review* **69**, 1979: 493–513.

Smith, A.

(1790) *The Theory of Moral Sentiments*, Oxford: Clarendon Press, 1976.

Sober, E.

(1980) 'Evolution, Population Thinking, and Essentialism,' *Philosophy of Science* **47**, 1980: 350–383.

Spector, M.

(1965) 'Models and Theories,' *British Journal for the Philosophy of Science* **16**, 1965–66: 121–141.

Spinoza, B.

(1678) *The Ethics*, pp. 43–271 of B. Spinoza, *Works of Spinoza*, vol. 2, N.Y.: Dover Publications, 1955.

Stearn, W. T.

(1971) 'Linnean Classification, Nomenclature, and Method,' Appendix to W. Blunt, *The Compleat Naturalist*, London: Collins, 1971.

Stoeber, M. and Meynell H. eds.

(1996) *Critical Reflections on the Paranormal*, Albany: State University of New York Press, 1996.

Stokes, D. M.

(1985) 'Parapsychology and its Critics,' pp. 379–423 of Kurtz ed. (1985).

Suppes, P. et al. eds.

(1973) *Logic, Methodology and Philosophy of Science* **IV**, Amsterdam: North-Holland, 1973.

Tait, P. G.

(1876) *Lectures on Some Recent Advances in Physical Science*, London: Macmillan and Co., 1876.

Tambiah, S. J.

(1990) *Magic, Science, Religion, and the Scope of Rationality*, Cambridge: Cambridge University Press, 1990.

Toulmin, S.

(1958) *The Uses of Argument*, Cambridge: Cambridge University Press, 1988.

(1961) *Foresight and Understanding*, London: Hutchinson, 1961.

(1973) 'Rationality and the Changing Aims of Inquiry,' pp. 885–903 of Suppes et al. eds. (1973).

Tylor, E. B.

(1871) *Primitive Culture* (2 vols.), London: John Murray, 1871.

van Brakel, J.

(1986) 'The Chemistry of Substances and the Philosophy of Mass Terms,' *Synthese* **69**, 1986: 291–324.

van Fraassen, B. C.

(1980) *The Scientific Image*, Oxford: Clarendon Press, 1980.

(1985) 'Empiricism in the Philosophy of Science,' pp. 245–308 of Churchland & Hooker eds. (1985).

Veblen, T.

(1909) 'The Limitations of Marginal Utility,' pp. 173–186 of Hausman ed. (1984).

von Weizsäcker, E. et al.

(1997) *Factor Four: Doubling Wealth, Halving Resource Use*, London: Earthscan Publications, 1997.

von Wright, G. H.
(1986) *Vetenskapen och Förnuftet*, Stockholm: Bonniers, 1987.

Wassermann, G. D.
(1981) 'On the Nature of the Theory of Evolution,' *Philosophy of Science* **48**, 1981: 416–437.

Weber, M.
(1903–06) *Roscher and Knies: The Logical Problems of Historical Economics*, G. Oakes tr., N.Y.: Free Press, 1975.

Weinert, F.
(1997) Review of *The Metaphysics of Science*, *Philosophy* **72**, 1997: 330–334.

Weyl, H.
(1949) *Philosophy of Mathematics and Natural Science*, Princeton: Princeton University Press, 1949.

Whewell, W.
(1847) *The Philosophy of the Inductive Sciences*, 2nd ed., London: Frank Cass & Co., 1967.

(1860) *Philosophy of Discovery*, Part 3 (vol. 4) of *The Philosophy of the Inductive Sciences*, 3rd ed., London: Parker and Son, 1858–1860.

Wigner, E. P.
(1967) *Symmetries and Reflections*, Bloomington: Indiana University Press, 1967.

Wilkerson, T. E.
(1988) 'Natural Kinds,' *Philosophy* **63**, 1988: 29–42.

Wilkinson, R. G.
(1973) *Poverty and Progress. An Ecological Perspective on Economic Development*, N.Y.: Praeger, 1973.

Wittgenstein, L.
(1953) *Philosophical Investigations*, Oxford: Basil Blackwell, 1972.

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