

REPORT FOR THE CHARDON LL HEARING

THE WHEEL OF HEALTH

Presented by Scientists for Global Responsibility
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INTRODUCTION

‘The Wheel of Health’ refers to the circular interconnection between soil, the organisms living in the soil, plants, animals and human beings --- and the ultimate dependence of all health on the quality of the soil. In these respects, the results of chemical agriculture are contrasted in this report with those of ecological agriculture. The evidence is overwhelmingly in favour of ecological farming. This fact alone makes a strong case against the introduction into commercial growing of any plant that is designed to be dependent upon chemicals, especially one that is intended for the nourishment of human beings or animals.

1. FARMING METHODS: YESTERDAY, TODAY AND TOMORROW

1.1 Ecological Farming Methods

1.1.1 Evidence on ecological farming from the 1930s

The title of this report is taken from a book of that name first published in 1938 by Dr G.T. Wrench (published by The C.W. Daniel Company Ltd., London; reprinted 1960 by Lee Foundation for Nutritional Research, Milwaukee, Wisconsin, U.S.A.; reprinted 1990 by Bernard Jensen International, Escondido, California). When a medical student, he asked himself: ‘Why study only disease? Why not study health?’ Eventually he came upon the writings of Sir Robert McCarrison, who went to India after receiving his medical qualification. At first he, too, studied disease amongst the native population. But while he was stationed as Agency Surgeon at Gilgit, at the north-east tip of Pakistan, he came into contact with the people of Hunza, a land in a high mountain valley some 60 miles further north. He wrote [p. 26 of Wrench]: ‘My own experience provides an example of a race unsurpassed in perfection of physique and in freedom from disease in general. I refer to the people of the State of Hunza, situated in the extreme northernmost point of India.... Amongst these people the span of life is extraordinarily long; and such service as I was able to render them during the seven years I spent in their midst was confined chiefly to the treatment of accidental lesions, the removal of senile cataract, plastic operations for granular lids, or the treatment of maladies wholly unconnected with food supply’. (McCarrison had been studying deficiency diseases). The cataracts and the irritation of the lids, he thought, might be caused by the smoke of heating the houses in winter. [Continuing on p. 27]: ‘During the period of my association with these people, I never saw a case of asthenic dyspepsia, of gastric or duodenal ulcer, of appendicitis, of mucous colitis, of cancer.... Among these people the “abdomen over-sensitivity” to nerve impressions, to fatigue, anxiety or cold was unknown.’

The Hunzakuts are an agrarian people, cultivating terraced fields. The many small fields are irrigated from a glacier. Everything that originates from the soil is returned to the soil.

[p. 123] 'It is possible also that in this form of [agri-]culture there is an excellence of vegetable health which can be obtained by no other means --- in Hunza, for example, there is that excellence, and plant disease is insignificant. It is possible that by full repayment to the soil we alone get a full return. ... When the soil sickens we restore it or strive to restore it by scientific doctoring; we return to it in the way of tonics the nitrogen, calcium, phosphorus, of which we have robbed it. Thus disease is patched and mended, but not abolished. The impoverishment of the soil remains our chief ill.'

[p. 125-127] Sir Albert Howard, Director of the Institute of Plant Industry at Indore, India, followed ancient Chinese principles of manuring as described in a book by Prof. F.H. King, *Farmers of Forty Centuries*. Sir Albert's method of plant breeding was applied on a farm at Surfleet, England, in 1935. 'The results of this Surfleet experiment of but two years' duration [evidently at the time Wrench was writing his book] have surprised those who have watched it. The vegetables not only have a richer flavour; not only have they a robuster appearance and their leaves a deeper green; not only do they keep better in storage like to that used by the Chinese and Hunza; but in their vegetable health they have attained a new standard. In a paper read by Howard to the Farmers' Club in February 1937 he spoke of the marked improvement in yield and quality of the vegetables, the better tilth and the increased earth-worm population (the Chinese are careful not to injure earth-worms or leave them uncovered by digging). The most striking feature was the general healthiness of the crops and the absence of insect and fungous pests. No chemical sprays have to be called into use. The plants themselves need no such doctoring.

'Baron de Rutzen, at the same meeting, related that eighteen months previously he had gone to Holland to observe a similar process. There he had noted "the extraordinary improvement of plant life in quality and in resistance to disease which apparently can be effected by this sort of method," as compared with sprays and other precautionary methods, with which "we had gone to the most absurd lengths."

'Mr Christopher Turnor similarly described his experience in Germany gained from visits paid in the previous two years. The farmers were building up the humus in the soil and abandoning the use of artificial manures.

'In Sind, in Rajputana, in the United Provinces, in Assam, the Punjab, in Bihar and Orissa, in Hyderabad, in Travancore, in Ceylon, in Kenya, and in Tanganyika, there are farms and estates in which the Indore methods have proved the same increased health of plants.'

[p. 129] Sir Albert Howard's crops at Indore continued to improve in health. He stated of the seven years he had been there, 'I cannot recall a single case of insect or fungous attack.' The animals feeding on these crops also prospered. Howard wrote: 'I was able to study the reaction of well-fed animals to epidemic diseases, such as rinderpest, foot-and-mouth disease, septicaemia, and so forth, which frequently devastated the countryside. None of my animals was segregated; none was inoculated; they frequently came in contact with diseased stock. No case of infectious disease occurred. The reward of well-nourished protoplasm was a very high degree of disease resistance, which might even be described as immunity.' To this, Wrench adds the comment, 'It will be noted by experts that the resistance covered diseases caused by filter-passing viruses, as well as those due to microbes.'

1.1.2 Evidence on ecological farming from modern times

Modern success stories of ecological farming can also be cited:

A two-year controlled experiment involving thousands of farmers in China showed the advantage of diverse agriculture over monoculture. 'Disease-susceptible rice varieties planted in mixtures with resistant varieties had 89% greater yield and blast [rice blast, the major disease of rice] was 94% less severe than when they were grown in monoculture. The experiment was so successful that fungicidal sprays were no longer applied by the end of the two-year programme.' (Youyong Zhu et al., 2000, *Nature* 406, p.718, 'Genetic diversity and disease control in rice')

'In Ethiopia, 12,500 farm households adopted sustainable agriculture methods, resulting in a 60 per cent increase in crop yields as well as a 70 per cent improvement of overall nutrition levels. (Soil Association and Sustain, *Myth and Reality*, 2001, p. 23; available at www.soilassociation.org [click on 'Publications'], which refers to J. Pretty, *Environment, Development and Sustainability*, 1, 253-274, 2000, 'Can sustainable agriculture feed Africa? New evidence on progress, processes and impacts')

Cuba faced serious hunger in 1989 when the collapse of the Soviet Union meant the withdrawal of Soviet aid. Thousands of city plots were handed over to local people who turned them into vegetable gardens. By 1998 more than 8,000 urban farms and community gardens were being run by more than 30,000 people [ref. (a) below]. The food produced is almost entirely organic and pest problems have diminished. Studies suggest that food security in Cuba has improved as a result [ref. (b) below]. (Soil Association and Sustain, *Myth and Reality*, 2001, p. 23; available at www.soilassociation.org [click on 'Publications'], which refers to (a) C. Murphy, Institute for Food and Development, report no. 12, May 1999, 'Cultivating Havana: Urban agriculture and food security in Cuba'; and (b) D. Meadows, *Organic Gardening*, USA, May 2000, 'Can organic farming feed the world?')

'Professor Jules Pretty of Essex University has shown how farmers in India, Kenya, Brazil, Guatemala and Honduras have doubled or tripled their yields by switching to organic or semi-organic techniques.' (George Monbiot, *The Guardian*, 24 Aug. 2000, 'Organic Farming Will Feed the World'. Reproduced with references added by the author at www.psrast.org/orgfarmmonbiot.htm . Referring to Jules Pretty, Feeding the world? *Splice*, the magazine of the Genetics Forum, August/September 1998, vol. 4, issue 6.)

Monocultural planting, which is used for GM crops, is itself a cause of problems. In an experiment now extending over seven years, conducted by the Universities of Minnesota and Nebraska, plots of identical dimensions were sown at various levels of diversity. The number of different species per plot was 1, 2, 4, 8 or 16. The individual species in each plot were chosen at random from a pool of 18 grassland perennials. It was found that productivity, measured in terms of biomass produced, increased with increasing diversity; for the plots containing 16 species, the biomass produced in 1999 and 2000 was about 2.8 times that produced by the average for the

plots containing a single species. It is possible that still greater productivity might result from still greater diversity. This correlation was observed to strengthen with time. Moreover, 'the high diversity plots are fairly immune to the invasion and growth of weedy species, but the monocultures and low diversity plots are difficult to maintain in that state.' (D. Tilman, P.B. Reich, J. Knops, D. Wedin, T. Mielke, and C. Lehman, 2001, *Science*, vol. 294, pp. 843-845, 'Diversity and productivity in a long-term grassland experiment'. The quotation is from a press release of the Institute of Science in Society, 6 November 2001, available at www.i-sis.org)

'Indian research showed that land reform and simple irrigation can boost crops by 50%, against only 10% increases from GM crops.' (*GM-Free*, vol. 1, no.2, 1999, p.15)

'Jose Lutzenberger, former Brazilian Minister for the Environment estimates that "backward Indians" produce at least fifteen tons of food per acre --- without fertilisers, pesticides, bank loans or governmental assistance.' (*The Ecologist*, vol. 30, no. 4, June 2000)

In Mexico, 100,000 coffee growers who adopted fully organic methods have increased yields by half. (*GM-Free*, vol. 1, no. 1, 1999, p. 15)

'In twenty Third World countries, more than 2 million families are farming sustainably on 4-5 million hectares, with tripled or doubled yields, fully matching if not surpassing intensive agrochemical agriculture.' (*The Ecologist*, vol. 28, no. 5, 1998, p. 318)

'A study in the United States reveals that small farmers growing a wide range of plants can produce ten times as much money per acre as big farmers growing single crops.' (George Monbiot, *The Guardian*, 24 Aug. 2000, 'Organic Farming Will Feed the World'. Reproduced with references added by the author at www.psrast.org/orgfarmmonbiot.htm. Referring to Peter M Rosset, 'The Multiple Functions and Benefits of Small Farm Agriculture in the Context of Global Trade Negotiations. Policy Brief prepared for 'Cultivating Our Futures', the FAO/Netherlands Conference on the Multifunctional Character of Agriculture and Land, 12-17 September 1999, Maastricht, The Netherlands. Co-published by Transnational Institute, Paulus Potterstraat 20, 1071 DA, Amsterdam)

'In East and southern Africa, some 250,000 families farming with sustainable agriculture have more than doubled their crop yields. In Indonesia, 400,000 farmers have adopted integrated pest management technologies for rice cultivation, cutting pesticide use to zero and yet still increasing yields. In southern Brazil, 38,000 farmers using green manures and cover crops have more than doubled their crop yields.' (Jules Pretty, *Living Earth*, no. 190, 1996, p. 8)

'High-tech farming ... is sowing ever greater problems. This year [2000], food production in Punjab and Haryana, the Indian states long celebrated as the great success stories of modern, intensive cultivation has all but collapsed [1]. The new crops the farmers there have been encouraged to grow demand far more water and nutrients than the old ones, with the result that, in many places, both the ground water and the soil have been exhausted.' (George Monbiot, *The Guardian*, 24 Aug. 2000,

‘Organic Farming Will Feed the World’. Reproduced with references added by the author at www.psrast.org/orgfarmmonbiot.htm . [1] Devinder Sharma, Green Revolution turns sour. *New Scientist*, 8 July 2000) (See also Dr Vandana Shiva, Reith Lecture, BBC Radio 4, 10 May, 2000)

1.2 Farming of GM Crops

1.2.1 Evidence on yields of GM crops

The US Department of Agriculture ‘analysed commercial crop results from 1997 and 1998 in regions where traditional and GM varieties of cotton, maize and soya were grown. It found no increase in yields from crops in 12 of 18 areas. (*GM-Free*, vol. 1, no. 3, 1999, p. 17)

Transgenic sugar beet and oilseed rape were also producing lower yields than conventional varieties. (*Farmers Weekly*,)

A report reviewing the results of over 8,200 university-based soya bean varietal trials in 1998 reaches the conclusions that, across all varieties tested, Roundup Ready soya beans yield, on average, 5.3 percent less than conventional ones; and, if only the top varieties of RR and conventional soya beans are compared, the Roundup Ready beans produce, on average, yields that are 6.7 per cent smaller. In some areas of the Midwestern United States, ‘the best conventional variety sold by seed companies produces yields on average 10 percent or more higher than comparable Roundup Ready varieties sold by the same seed companies.’ (Dr Charles Benbrook, Ag BioTech InfoNet Technical Paper Number 1, 13 July 1999, ‘Evidence of the Magnitude and Consequences of the Roundup Ready Soybean Yield Drag from University-Based Varietal Trials in 1998’, p. 1; available at <http://www.biotech-info.net/troubledtimes.html>) These results were confirmed for 1999 and 2000, as well. (p. 28; available at <http://www.biotech-info.net/troubledtimes.html>)

‘The Mississippi State Court of Appeals affirmed a lower court ruling that held the Jacob Hartz Seed Co., a Monsanto subsidiary, responsible for reduced yields in its genetically modified soybeans that farmer Newell Simrall had planted. ...

‘Hartz had touted its Roundup Ready soybean seeds as “top quality, disease resistant, high yielding seeds,” according to the court opinion.

‘As the 1997 growing season progressed, Simrall noticed that the soybean plants ... were shedding their pods. ... Agronomy experts found that the “disease resistant” transgenic beans had contracted the soybean mosaic virus.’ (CropChoice news, 29 Sept. 2001, <http://www.cropchoice.com/leadstry.asp?RecID=475>; the ruling is at www.mslawyer.com/mssc/ctapp/20010925/0000137.html ; quoted from www.btinternet.com/~nlpwessex/Documents/Missourisoybeans.htm)

‘A study recently published in “Aspects of Applied Biology” [1] has produced some interesting findings in relation to transgenic oilseed rape varieties developed by Aventis, the principal commercial participant in the UK’s controversial fieldscale trials for GM crops.

‘ ... The study confirms that:

- compared to conventional rape hybrids[,] mean yields from the transgenic varieties were lower.
- compared to conventional rape hybrids[,] yields of the transgenic varieties showed a higher degree of variability.
- the transgenic varieties usually produced reduced financial returns when treated with herbicides compared to when receiving no herbicide treatment at all (any small increases in yield derived from weed control were usually insufficient to cover the extra cost of the herbicide, including glufosinate ammonium).’ [1] *Aspects of Applied Biology* 55, 1999, ‘Production and Protection of Combinable Break Crops’. (NLP Wessex, 17 April 2000, www.btinternet.com/~nlpwessex/Documents/gmtrials.htm)

[We may note that glufosinate ammonium is also the herbicide to be used on Chardon LL.]

In the US, 190 farmers are suing Monsanto because much of their GM cotton withered in the field.

Elsewhere in the US, farmers are suing Monsanto for fraud and misrepresentation in regard to Bt cotton crop failures (which are engineered in a different way from those above).

Steve Lee, an American farmer who planted Roundup Ready cotton, watched his crop fall over and break at the base as a result of root deformities. He said, ‘In all my 36 years of farming, I have never seen anything like this.’ (*GM-Free*, vol. 1, no. 1, 1999, p. 21)

‘Monsanto planted 500 hectares of GM cotton within 9 districts of Sulawesi, Indonesia in open “field trials”’. ... ‘It transpires that the GM cotton failed to out-perform the indigenous variety in all but one of the 9 districts. Worse yet, the GM cotton succumbed to drought and the brown hopper. Vivid photographs showed the browned-out GM cotton field next to the lush green field of indigenous cotton, which is resistant to both drought and the brown hopper. (Dr Mae-Wan Ho, on a visit to Jakarta; ISIS press release, 15 Feb. 2001; www.i-sis.org)

Research has been slowly emerging from US universities demonstrating that GM crops rarely provide economic benefits to farmers. Either yields are disappointing or the anticipated cost savings are not materialising. Until now it has been assumed in many quarters that the one genuine GM financial success story for US farmers has been Bt cotton. While Bt cotton suffers reduced damage from 'bollworm', 'European corn borer' and 'fall armyworm', in some cases by around 50-60%, the damage to cotton bolls from 'stink bugs' has increased in Bt cotton by a staggering 430% over damage to conventional cotton. The latest report from North Carolina State University shows that there is no financial gain to be had for farmers from growing Bt cotton --- in fact the latest figures show that normal cotton is marginally (\$2 per acre) more profitable. There is now not a single major GM commodity crop in the US which has successfully delivered what was originally promised of it by probiotechnology academics and industry.

(www.btinternet.com/~nlpwessex/Documents/geneticsmyth.htm, April 2000)

In Georgia (the country, not the US state), the GM potato crop failed, yielding only a third of that expected. Several farmers are now in debt. (*Environment & Health News*, vol. 3. edition 3, 1998, p. 12)

1.2.2 Evidence on chemical use with GM crops

The US Department of Agriculture ‘analysed commercial crop results from 1997 and 1998 in regions where traditional and GM varieties of cotton, maize and soya were grown. ... Farmers in 7 of 12 areas used the same amount of pesticide as those growing non-GM crops.’ (*GM-Free*, vol. 1, no. 3, 1999, p. 17)

‘RR soybeans clearly require more herbicides than conventional soybeans, despite claims to the contrary. ... Monsanto has manipulated comparative data on RR and conventional soybean herbicide use in ways that fall between misleading and dishonest.’ (Dr Charles Benbrook, Ag BioTech InfoNet Technical Paper Number 4, 3 May 2001, p. 2; available at <http://www.biotech-info.net/troubledtimes.html>)

A report reviewing the results of over 8,200 university-based varietal soya-bean trials concluded that: ‘Farmers growing RR soybeans used 2 to 5 times more herbicide measured in pounds applied per acre, compared to the other popular weed management systems used on most soybean fields not planted to RR varieties in 1998. RR herbicide use exceeds the level on many farms using multitactic Integrated Weed Management systems by a factor of 10 or more.’ (Dr Charles Benbrook, Ag BioTech InfoNet Technical Paper Number 1, 13 July 1999, ‘Evidence of the Magnitude and Consequences of the Roundup Ready Soybean Yield Drag from University-Based Varietal Trials in 1998’, p. 2; available at http://www.biotech-info.net/RR_yield_drag98.pdf.)

‘Soybean farmers in the Midwest [of the United States] are ... reporting that velvetleaf and smartweed species are tolerating application rates of Roundup [the herbicide used with Roundup Ready soybeans] that were effective just last year. Over the next few years, weed scientists anticipate that the gradual shift toward weed species that can tolerate Roundup will continue, requiring farmers to change their mix of practices. If even a small percentage of growers respond instead by just increasing rates of Roundup application and/or spraying more often, this could ... lead to the emergence of genetically resistant strains of commonplace weeds. In all likelihood these strains would quickly spread and all growers would then have to switch to other herbicides and control tactics.’ (Dr Charles Benbrook, Ag BioTech InfoNet Technical Paper Number 1, 13 July 1999, ‘Evidence of the Magnitude and Consequences of the Roundup Ready Soybean Yield Drag from University-Based Varietal Trials in 1998’, p. 6; available at http://www.biotech-info.net/RR_yield_drag98.pdf)

1.2.3 Further evidence on GM crops from around the world

Total output and nutrition per acre are higher where biodiverse farming is practiced, although, of course, the *yield* of a individual crop is not as great as with monoculture. Biodiversity provides not only vegetables and fodder but also medicines; and it

protects the soil from erosion by wind and water. (Dr Vandana Shiva, Reith Lecture, BBC Radio 4, 10 May, 2000)

In India, areas like Punjab that used to be prosperous in agriculture are experiencing an epidemic of suicides by farmers. The farmers have become heavily in debt with the introduction of modern technological methods of farming. Large stretches of land have become unproductive. Trees have stopped bearing fruit because the heavy use of chemicals has killed the pollinators. (Dr Vandana Shiva, Reith Lecture, BBC Radio 4, 10 May, 2000)

In areas in India where farmers have converted from chemical monoculture to organic farming, the farmers have been able to pay off their debts and to increase their income threefold just from the savings on inputs. The previous disenchantment of these farmers is now replaced by excitement and enthusiasm. (Dr Vandana Shiva, Reith Lecture, BBC Radio 4, 10 May, 2000)

A US farmer who has been growing GM crops for four years has travelled to Britain to 'raise a warning flag'. Corky Jones grows Monsanto's GM soya beans in Nebraska. He said that the performance of those crops is 'disappointing'. Moreover, he says that Monsanto is now cautioning against feeding these soya beans to children, ill persons and the elderly. He had been told that his soya-bean yield would increase by 10 bushels; but, in fact, he has been getting 8-10 bushels *less*. He was told the crops would need only half the usual amount of pesticide; in fact, since the second year, he is using *more*. In the first year, he used 1 litre per acre, but now he requires 2-3 litres. If he were growing non-GM, he would need between 1 and 2 litres per acre. US farmers were Monsanto's guinea pigs, says Corky Jones.

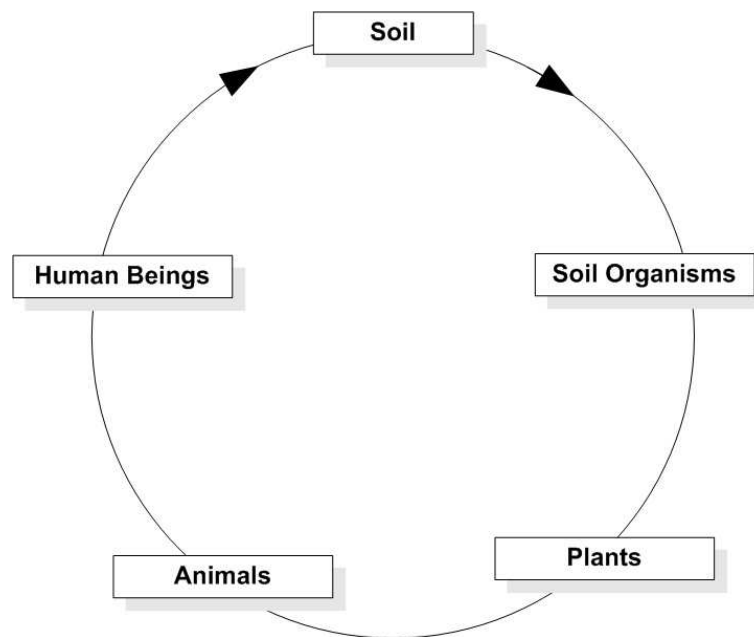
At first, he had thought that the faults must have been due to some unfavourable circumstance during that growing season. However, the situation became worse in subsequent years. 'Many, many farmers' to whom he has spoken have had the same results. Planting of GM soya beans and maize is decreasing, he says, and now 80 % of soya beans planted are conventional and only 20% are genetically modified. Speaking at the same meeting, Jim Goodman, an organic farmer from Wisconsin, said that as weeds develop resistance to a herbicide, further measures must be taken to control them. Thus Monsanto has obtained a patent for additional herbicide to be added to *Round-Up*. Farmers will be locked-in to buying this herbicide. (Meeting held at Norwich on 19 March 2002, organised by the Small and Family Farms Alliance with the support of Shepdrove Organic Farm.)

GM crops, like conventional crops, depend on the use of fertilisers; but 'Dr David Fleming, Director of the Lean Economy Initiative in the *Times* of 3rd February [2000], warned that agricultural policy is blind to the total transformation that lies ahead: "As the Middle East Opec producers capture a share of the market well in excess of the 30 percent that allowed them to dominate it in the 1970s, oil prices will move fast and far. Present-day food security worldwide is wholly dependent on cheap oil for fertilisers, for its labour-displacing methods and for its imports." '(Quoted in *Farm and Food News*, published by the Farm and Food Society, March 2000, p. 4)

2. EXAMINING THE WHEEL OF HEALTH

2.1 The Circular Dependence

The food chain is, or should be, a closed circle. The soil is the fundamental basis that nourishes soil organisms, which encourage healthy plant growth, which, in turn, produces healthy animals and ultimately healthy human beings. All the material taken from the soil by plants, animals and human beings ought to be returned to the soil to replenish it; otherwise, the soil is mined and gradually declines in both quality and quantity, dragging down with it the health of the entire chain.



2.2 Soil

‘A series of experiments comparing soil qualities under organic and non-organic management in the US led researchers to conclude that all topsoil in the non-organic managed areas would be lost in 50-100 years unless topsoil management practices were improved. In the organic system, however, the soil management minimised erosion ...’ (Soil Association and Sustain, *Myth and Reality*, 2001, p. 23; available at www.soilassociation.org : click on ‘Publications’)

‘It is a common misconception that the addition of organic matter automatically means improved soil structure. In reality improved soil structure is a consequence of processing of the organic matter by soil organisms. In a lifeless soil organic matter persists unprocessed offering little in the way of benefit until the biological components are once again able to thrive. Like nutrient cycling [as we shall see below] it is no single soil organism that is responsible for improving soil structure. [Soil Association on-line Library, available at www.SoilAssociation.org: Briefing Paper, ‘Soil Biodiversity’, p. 2]

‘Earthworms and small arthropods digesting organic matter increase its surface area substantially. The resulting faecal pellets can then form aggregates with existing soil

particles. In addition the burrowing activity of these organisms serves to increase the porosity and water holding capacity of the soil. At a microbiological level the root system or hyphae of fungi stretch throughout the soil, helping to bind soil aggregates. Furthermore, the bacteria in the soil secrete sugary gums (polysaccharides) that act like glue binding soil particles together to form soil aggregates.

2.3 Soil organisms

2.3.1 Functions of soil organisms

[This section, except where otherwise noted, is based on two papers in the Soil Association's on-line Library, available at www.SoilAssociation.org: Briefing Paper, 'Soil Biodiversity', denoted by 'BP'; and Overview, 'Soil --- The Importance and Protection of a Living Soil', denoted by 'OV'.]

Plants are unable to utilise directly the mineral and organic matter in the soil. Lacking enzymes, they are reliant on the larger fauna in the soil to begin the process of breaking down organic matter, and on micro-organisms to continue the breakdown and ultimately to deliver nutrients to the roots of plants. These processes will now be described in more detail.

Earthworms, snails, insect larvae, small arthropods and other creatures macerate the particles of organic matter and, through the digestive process, increase the nitrogen content. Worms and other organisms also drag material from the surface of the soil to the interior. Air, light and water also contribute to chemical decomposition, but most of the organic molecules are too complex to be degraded to a product useful to plants except by biological activity. Protozoa and nematodes contribute to the nourishment of plants by excreting ammonium, manufactured from the excess nitrogen they obtain by eating bacteria (which contain higher concentrations of nitrogen than do the protozoa and nematodes).

'Without the activity of micro-organisms, the nutrients in the sub-soil, the mineral fractions of the top-soil and in organic matter would never become available to plants. Plants do not have digestive systems; they do not produce their own enzymes to break down substances. Instead they rely on the diverse range of biological life in the soil for this function.' [OV, p.4e]

It is the micro-organisms, especially fungi and bacteria, that possess the enzymes needed to break down the large molecules left by the earthworms and other small soil creatures. A huge variety of enzymes is required to break a long molecular chain at various points; and many different micro-organism are needed to supply these enzymes. Once the molecules are simple enough, they can be taken up by plants. However, the micro-organisms will first have supplied their own needs; and neither the quantity nor the range of the molecules remaining is sufficient to support healthy plants.

At this point in the 'food chain' of many plants, a type of fungus called 'mycorrhiza' assists by colonising a large fraction of the roots. The mycorrhizae improve the

absorption of water and nutrients of the plant, while receiving carbon from the plant in a symbiotic relationship. 'Root uptake of nutrients is enhanced by mycorrhizae, due to the larger nutrient-absorbing surface provided by the fungi. This area has been calculated to be up to ten times that of roots without mycorrhizal fungi.' (quotation from Soil Association, *Organic farming, food quality and human health*, 2001, p. 10, col.2c)

There are enormous numbers of soil organisms performing the tasks described. 'One gram of healthy soil can contain over 1 billion organisms of over 10,000 different species.' [BP, p. 5]

In addition to supporting the healthy growth of plants, soil micro-organisms also contribute to plant health by suppressing mechanisms that lead to disease:

- by providing a physical barrier against pathogens, both around roots and on leaves;
- by out-competing soil pathogens;
- by attacking harmful fungi;
- by producing chemicals, some of which are likely to be harmful to soil pathogens;
- by triggering a mild immune response when they come into contact with roots, thereby inoculating a plant against future contact with pathogens. [BP, p.4]

The role of earthworms has been mentioned above. 'A number of studies have shown that organic management promotes measurably higher levels of earthworm numbers than conventional soils (eg. Lampkin [N.], 1992).' [*Organic Farming*, Farming Press Books] (Soil Association, *The Biodiversity Benefits of Organic Farming*, May 2000, p. 33)

A major US seed dealer says there is evidence that earthworms are dying as a result of the effects of Bt maize, a GM variety designed to produce a toxin within its cells. (American journalist Steven Sprinkel, as reported in *GM-Free*, vol. 1, no. 4, 1999, pp. 5, 6.) Although Chardon LL is based on an externally-applied herbicide rather than an internally-produced pesticide like that in Bt crops, it is cause for concern that this effect on earthworms was either unforeseen or ignored and is coming to light only after the Bt crop has been widely planted.

'[N]on-organic farming relies on soluble fertilizers to maintain fertility of the soil, while organic farming relies on a high level of biological activity in the soil and nitrogen-fixing crops. For example, beneficial fungi such as mycorrhiza are more common and more active in organically managed compared to non-organically managed soils. Plants benefit from mycorrhizal colonies through improved take-up of minerals, crop vigour and higher resistance to soil-borne pests and diseases.' (Soil Association and Sustain, *Myth and Reality*, 2001, p. 23)

'The use of chemical fertilisers, herbicides and pesticides can inhibit the microbiological life in the soil ... ' (Soil Association, *Organic farming, food quality and human health*, 2001, p. 11, col. 1c)

2.3.2 Effects of GM crops on the functioning of soil organisms

'Pest resistant GM (Bt) crops are exuding pesticides at unpredicted levels (examples from the US); producing 10-20 times the amount of toxins of conventional pesticides and leaching toxins into the soil, with negative effects on insect larvae.' (Soil Association, *The Biodiversity Benefits of Organic Farming*, May 2000, p. 34) This is another example of an unforeseen or ignored consequence of a genetically engineered crop.

A group of nine experts on soil ecology and related subjects has produced a report warning that GM genes leaking out of crops into soil micro-organisms (a process that has been experimentally demonstrated) and transferred directly ('horizontally') into different species of micro-organisms (also demonstrated) may result in altered behaviour leading to reduced soil fertility. In the worst case, the suggested mechanism might cause irreparable, cumulative damage to soil fertility and the GM genes might spread uncontrollably over vast areas. (www.psrast.org/soilecolart.htm, 'Genetically Engineered Crops – A Threat to Soil Fertility?', April 2001; summary in www.psrast.org/soilfertfact.htm)

A paper on 'Impacts of Transgenic Plants and Micro-organisms on Soil Biota' concludes: 'This review of the impacts of GMOs on the soil biota and processes demonstrates the current paucity of scientific knowledge available to support risk assessment of GMOs. Laboratory and limited field experimentation has shown that transgenic plants and micro-organisms introduced into soil have sometimes caused statistically significant changes in the structure and function of indigenous soil biota.' ... 'The effects of genetic modification on interactions between components of the soil/plant system may not be evident *in vitro*.' ... 'It cannot be excluded that HGT [horizontal gene transfer] from plants to bacteria by transformation may take place in certain environmental niches, such as the digestive gut of soil insects, which have been suggested as optimal for gene transfer events ... However, the ecological significance of such rare events depends on the selection of the acquired trait. If transfer of novel genes to bacteria provided transformants with a selective advantage or ability to occupy a new niche, multiplication of the bacterium and its transgene could be expected. ... Despite difficulties with the interpretation of experimental results, the occurrence of some ecological perturbations induced by GMOs suggests that until methods and theories for establishing ecological significance are developed and verified, the potential ecological impacts of GMOs released into the environment will need to be evaluated on a case by case basis. The frequency of reports of detectable changes in soil biota is perhaps somewhat unexpected, given that research into this area has only recently begun. The long-term implications of these changes in soil must be assessed.' (M. O'Callaghan and T.R. Glare, 2001, 'Impacts of Transgenic Plants and Micro-organisms on Soil Biota', 54th Conference Proceedings (2001) of The New Zealand Plant Protection Society Incorporated; www.hortnet.co.nz)

2.4 Plants

[N.B.: Here and in following quotations from this publication, primary references are listed there but are not reproduced here.]

Location of a quoted extract in the publication is given by page number and placement on the page, which is normally divided into two columns. Position within a column is designated by letters 'a' through 'e', with 'a' at or near the top of the page.]

'Studies have shown a link between excessive nitrogen fertilisation and increased plant susceptibility to pests and disease, necessitating the use of insecticides and fungicides. Plants provided abundantly with nutrients, especially with nitrogen, are more likely to be attacked by aphids, while plants manured organically are less or not at all affected by aphids due to the lower water contents and thicker cell walls of the plants. Crop losses due to insects have increased by around 20 per cent since 1945 despite a 3,300 per cent increase in the amount of pesticides used. The thicker cell walls of organically managed crops may also protect them from disease, as was found in a study with maize.' Soil Association, *Organic farming, food quality and human health*, 2001, p. 59, col. 1e)

'Genes interact with those around them. As a result of the random location of the inserted gene and absence of regulating factors, unknown interactions can take place between the inserted gene and the rest of the plant genes, causing unexpected outcomes that can impact on any characteristic of the plant, and could even disrupt beneficial processes. Unexpected changes that could affect the nutritional quality or allergic potential of the resulting crops have been identified in genetically modified (GM) rice and soya. It is hard to see how all the unintended and unexpected consequences could be identified and excluded from GM seeds. Indeed, in the US some side effects have been identified in GM crops only once they were being commercially grown. (Soil Association, *Organic farming, food quality and human health*, 2001, p. 22, col. 1d)

2.5 Animals

'Animal studies show better growth and reproduction in animals fed organically grown feed compared with those fed non-organically grown feed. Worthington [1999] concludes "Reproductive health, incidence and recovery from illness are sensitive measures of health status and should be given appropriate weight. Taking all of this into account, the available data is very strong with regard to the health benefits of organic feed and food.'" Soil Association, *Organic farming, food quality and human health*, 2001, p. 65, col. 1d)

'Linder [1973] asserts "These kinds of experiments (animal preference tests) clearly indicate that there are differences in the quality of food grown with organic as compared with mineral fertiliser. They leave no doubt that the content of these quality differences should be fully established and the implications of such differences on human and animal nutrition assessed." Woese *et al's* more recent [1997] review of this issue concluded that "animals distinguish between the foods on offer from the various agricultural systems and almost exclusively prefer organic produce. The reason for this preference is not known.' (Soil Association, *Organic farming, food quality and human health*, 2001, p. 49, col. 1e)

This ability of animals to distinguish between organically grown food and non-organically grown food may be related to the phenomenon of animals choosing organically grown or conventionally grown crops to GM crops, mentioned in our report on ‘The Non-Suitability of Genetically Engineered Feed for Animals’.

Commenting on the outbreak of BSE (and the total absence of the disease amongst animals born and bred on organic farms), Patrick Holden, Director of the Soil Association, wrote: ‘It is almost as if consumers have become laboratory animals in the huge experiment that is industrialised agriculture, storing up untold health problems for the future. Chemicals such as DDT and lindane have been banned [only] after the initial dismissal of safety concerns. **Research in animal feeding trials has indicated that health effects often only reveal themselves over long time spans, sometimes even over successive generations.**’ [Emphasis by bold-faced type is mine.] (Soil Association, *Organic farming, food quality and human health*, 2001, p. 3, col. 2a)

2.6 Human beings

Although the Food Standards Agency declares that organic food is no more nourishing than conventional food, the Soil Association has pointed out that, of the 99 studies on which it based this opinion, 50 trials included ‘organic’ produce that had not, in fact, met proper organic standards; and 20 more studies were not useful, either re-publishing parts of other studies already included or testing for qualities not relevant to the review; only 29 studies remained as valid. Even these studies form a heterogeneous group and cannot properly be compared. However, if the comparison is made, the results show that at least 50% of those studies that made analyses of minerals or vitamins indicate higher content of both minerals and vitamins in organic produce, while (with the single exception of one study showing lower content of minerals) the remaining studies showed inconsistent or insignificant results. (Soil Association, *Organic farming, food quality and human health*, 2001, p. 32-37)

Further evidence of the superiority of an organic diet comes from the medical sector, and three such examples are given below.

The British Society for Allergy, Environmental and Nutritional Medicine states: ‘We have long believed the micronutrient deficiencies common in our patients have their roots in the mineral-depletion of soils by intensive agriculture, and suspect that pesticide exposures are contributing to the alarming rise in allergies and other illnesses.’ (Soil Association, *Organic farming, food quality and human health*, 2001, back cover)

An ‘experiment’ on the effects of eating organic foods was made at a school. ‘There are reports of positive health effects in humans resulting from the consumption of organically grown foods. A report published in 1940 tells of the improved health of students at a New Zealand boarding school that began serving almost exclusively organically grown produce. After three years a report was submitted that made the following observations of the pupils: a period of detoxification upon arriving at the school, lower incidences of catarrhal conditions, a “very marked decline” in colds and influenza, more rapid convalescence, excellent health generally, fewer sports injuries,

a greater resilience to fractures and sprains, clear and healthy skin, and improved dental health.’ (Soil Association, *Organic farming, food quality and human health*, 2001, p. 47, col. 1d)

‘More recent clinical evidence comes from doctors and nutritionists administering “alternative” cancer treatments who have observed that a completely organic diet is essential for a successful outcome. Nutritional cancer therapies involve avoidance of pollutants and toxins as much as possible, the exclusive consumption of organically grown foods and increases in nutrient intakes, and have yielded good results. The Nutritional Cancer Therapy Trust reports “the overwhelming number of patients following alternative cancer therapies are those who have been declared terminal, with minimal life expectancies following initial allopathic treatment. The ability of these patients to gain remission from all clinical evidence of cancer is therefore very significant.’ (Soil Association, *Organic farming, food quality and human health*, 2001, p. 48, col. 2a)

‘While improvements have occurred in disease treatment, there has been a general decline in public health as indicated by increases in allergies, obesity, osteoporosis, diabetes, food intolerances, cancers, cardiovascular disease, infertility, sexual development disorders, respiratory sensitivity and mental health problems. Many doctors and nutritionists believe that the cause of this rise in degenerative diseases is two-fold: an increase in the amount of stressors and toxins [including residues of agrochemicals] our bodies are exposed to, and a decrease in the amount of nutrients in people’s diet needed to deal with those stresses. The result is commonly more cellular damage, more degenerative diseases, and a declining quality of life for many.

‘Linus Pauling, winner of two Nobel prizes, believed “Every sickness, every disease, and every ailment can be traced to a mineral deficiency”. Supporting this hypothesis, the United States Department of Agriculture reported, 30 years ago, that the highest death rate areas in the US generally corresponded to those where agriculturists had recognised that the soil was depleted.’ (Soil Association, *Organic farming, food quality and human health*, 2001, p. 11, col. 1e)

3. CONCLUSIONS

In Britain and in many other countries where food produced by chemical agriculture is consumed, plants and animals, including human beings, enjoy a moderate standard of health. On the other hand, consumption of organically produced food has been shown to lead to superior levels of health, vitality and freedom from disease. Moreover, chemical methods of farming have adverse effects on soil, which is increasingly depleted and degraded. In India, the ‘Green Revolution’ of chemical monoculture has already resulted in the devastation of once-productive agricultural regions and in the inducement of nutrient-deficiency diseases in the population from lack of variety in the diet.

Genetically engineered plants are a further step along the road of chemical agriculture, with the added hazards of introducing unknown and uncontrollable complications. Amongst these is the possibility of disrupting the complex interactions of soil organisms through the horizontal transfer of genetically engineered genes,

which may lead to progressive loss of soil fertility not only on farms but over ever-expanding areas surrounding them.