(lode5-98)

(Notes on a meeting at Lode on 27.5.98, Alan and Gerry)

'Thoughts on the approach to the Dartford Tunnel' (Gerry)

(see accompanying diagrams)

1. The limits to any specific technology are foreseeable; they are physical laws which set inevitable limits on developments. They are in the physical world what the laws of diminishing marginal returns are in the economic.

2. Modernity has occurred through a process whereby one meets a limit and then people find a new way round that limit - as in the case of grain production.

3. The limits produced by many technologies are very low. For example, wheat and rice only convert about 1% of the sun's radiant energy into energy consumables by human beings. Sugar cane converts about 3%. Hence if the DNA of sugar-cane could be used in grains, there might be a dramatic increase...

4. There is a limit to any agricultural production. The agricultural revolution consisted of the use of different combinations of atoms. The limits are defined by the ways in which the electrons are constituted by the different relations of carbon, hydrogen and oxygen. The same is true of steel. This is the chemistry of history.

5. The innovation of artefacts is a matter of inching one's way up to the limits and then, when reached, finding other ways of reaching an even higher limit.

6. An example is Wrigley's account of the use of coal. There were limits in the pre-coal world. Coal released the stored energy of fossil fuels.

7. The development of transport is largely a matter of changing the ways in which the energy locked up in fossil fuels is used. Trains - coal; cars - petrol; aeroplanes - aviation fuel and the release from the friction of rolling wheels; rockets - the controlled use of stored energy.

8. There are practical limits at every stage - for example the friction of wheels and of air. There are a combination of limits.

9. Historically, as in one above, one reaches a limit and then finds a way round it.

10. An example is the application of Mendel's work on plants to plant-breeding. This did not increase the bio-mass of the plant very much, but it allowed one to select out a higher proportion into grains and less into leaves and stalk.

11. Always one is limited by physical laws, which are dependent on the electronic configurations of the atoms in the artefacts (John Ziman territory).

12. The turn back at the top of the S curve that one finds with all artefacts is not an accident; it is built in by physical principles.

13. One of the great mysteries is how you get from A to B (see diagram), that is to say how one gets from almost zero up to a level where a new artefact can beat the competition.

14. This is a problem which we faced with the epistemology group.

15. When discussing the problem of how humans were able to get further and faster than normal evolution (BVSR), with James Black, James Fleck and John Ziman, the conversation went something like this:
Gerry - We need to understand the brain better - what goes on in the mind?
John Ziman - I don't understand how the brain works in innovative work.
James Black - I've come to look on the brain as a comparitor, that compares things.

16. The last idea is helpful. How can we use it to explain how one gets from A to B. At A the conceptual space is full of data. The move from A to B is the history of the improvement of function.

17. One is comparing functionality. But what are functions? The number of functions seems to be quite small. The resources one needs seem largely to be covered by the human needs for food (agriculture), shelter (housing, clothing), predation (on others - war, by other species - disease)

18. Curiosity is the prime mover in giving humans new resources. The rapid growth of curiosity seems the major characteristic of humans & is well displayed in the table in the book on Neanderthal Man (p.198) which shows that as the proportion of homo sapiens increased, so there was a sudden explosion of new technologies about 40,000 years ago.

19. Predating is particularly important, both humans on each other, and humans on and by other species (including disease). This gives rise to a lot of functional 'technology'.
Another important technology is concerned with the need to move over the surface of the earth - communications.

20. A factor which is also important is the amount of data in the conceptual space, which is crucially affected by travel and exploration (creation of differences), the storage techniques (especially writing) etc.

21. Returning to the mind as a comparitor, what it seems to do is to take two pieces of data or information, A and B, then bear in mind a function (e.g. desire to keep warm) or goal (which is to improve the function - more food per acre or whatever). The brain then moves between A and B, comparing them as ways of achieving the goal. But it then does something which 'nature' (evolution in its blindness) cannot do. It looks at the functions and considers the possibility of using the data to produce **more** of the function.

That is to say it tries with tacit knowledge and science to see whether a conjecture produces more or less of a given function.

22. Thus the brain has the ability to look sideways, so to speak, to project beyond the given. Represented in one way, one has the following situation (where A and B are bits of data being compared by the brain).

<- A B -> C

Humans have the ability to conceive of 'C', which is at first imagined or guessed, as a projection beyond anything yet known, moving further along a line of more or less of a desired functional goal. This is the human ability.

23. Thus humans have the ability to imagine possible outcomes that have not yet been achieved, by projection from what has been achieved.

24. When new knowledge comes in, the function (goal) is to 'attractor', in other words gives the energy or focuses the attention. The human tries to do better than ever. A scientist tries to do this by putting in more data.

25. Returning to the diagram of how one moves from A to B; at the start the efforts are so much inferior to the best available solutions that they have no practical pay-off. So to start with they can only be fun - play, hobbies etc.

26. In this playful period, we work by taking data, by comparing things, by projecting beyond the present up and down, by trying experimentally, by the use of tacit knowledge.

27. If the play or hunch is right, one will finally produce an artefact that performs the function at least as well as the previous approach - but usually only after a long development.

28. An example of very early use of the 'comparitor' approach is in early hominid flint-knapping. Humans improve on tools - sharpening flints, imagining within a stone a sharper stone. This seems to be absent in other mammals - who use tools, but do not improve on them.
In some ways the scientific revolution can be seen as a massive project to set up nature for the purposes of comparison.

29. Is the activity of modern scientists very different from these early flint-knappers? What scientists do now is to manipulate data massively on computers. They seek the relations between atoms-energy etc. and they calculate this. They use binary arithmetic to calculate quantities.
But all this sophisticated mathematics, and all the binary or digital activity of the computer, is concerned with more or less. The whole of science can be looked upon as a massive enterprise, concerned with comparisons of more or less. What scientists do in computing is to see more or less, additions and subtractions.

30. This activity is still based on the ability of the human mind to project beyond the comparison, to visualize the possible.

31. This is where humans are different from 'blind nature', which cannot guess at the possible. All that nature (including animals) can do is to try every possible combination and retain those that 'work' (blind variation and selective retention). Humans do not work like this. They can narrow down the choices with their imagination, they can take short cuts, thus they can outpace evolution.

32. A central feature of modernity is that, having guessed at differences or patterns, we have established methods of trying out whether our guesses or short-cuts work - that is the experimental method.

33. In this process, a scientist has to have an improved function in mind. For example, in the desire to improve the functionality of medical prevention of disease. The way of blind variation is represented by fungi, which developed powerful anti-biotics in their spoors to protect themselves, through a process of natural selection. Fleming spotted the potency of this in one particular case - penicilin. From this, other scientists thought sideways and now there are a whole range of anti-biotics based on the molecules developed by fungi.

34. This happened because when Fleming published his results, through the process of bounded but leaky, lots of people used the data in their pooled conceptual spaces and a whole area of thinking developed where numerous highly trained minds were focuses on the properties of fungi.

35. This partly explains the difficulty which one might foresee in the development of artefacts. As each better artefact is developed, the level which the next break-through has to reach is much higher (as in the diagram, the gap between C and D). The difficulty appears to grow in a non-linear way. But so does the ability to innovate, because each increase in reliable knowledge and artefactual improvement also leads to the non-linear growth in the ability to innovate.

36. Returning to the 'comparitor' method, it would appear that the larger the gap between the data being compared, the larger the realm of the possible becomes. Humans need difference to make meaningful comparisons. If things are very alike they imagine anything different from those that exist.

these differences mainly consist in the differences over time (the stimulus of living in a rapidly changing society), and differences over space (rapidly expanding societies). Both of these are major differences between, say, England and Japan in the eighteenth century.

37. Innovation depends very much on the market for new ideas and artefacts, i.e. the 'attractor'. This is because artefact innovation depends almost totally on the strength of the desire to improve the existing function - which depends on the stimulus to do so.

38. One of the things which bring about clashes or comparison and hence stimulates the 'comparitor' activity, is the bringing of hitherto distant data together. Thus all increases in the speed and range of communications (as in the improvements in navigation in Europe in the early modern period) encourages imagination.

39. Competition and conflict, as in nature, tends to force comparitor behaviour. In particular the pressures of predation - the threat from and to other humans, animals, bugs etc - tends to speed up the process.

40. A very important area where a lot of the 'comparitor' behaviour, and the 'trying out' of wild schemes and possible strategies takes place is in those characteristically human activities, games, hobbies and 'art', which are much more about basic survival strategies than one would realize.

41. It will be important to study the rate of change in the material world and the effects of these rates of change on the mental world.

42. One can assume that humans are naturally endowed with curiosity; but this curiosity is inhibited or trapped by various pressures.

43. A fruitful area for the study of the principal of 'bounded but leaky' is in Chinese writing. One can see the direct descent from oracle bones, thousands of years ago. It changed little and its 'functionality', as measured against alphabetic writing for example, grew less and less. China was bounded, with few leaks. The pictographic system became more and more unsuitable for the generation or dissemination of knowledge.

Europe was very leaky, adopting what was functionally most efficient (e.g. Arabic numerals). These differences in language and numerals then underlie the growth differences in many other things such as the relative development and effects of mathematics and printing.