Organisational Analogies
Project Report

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Executive Summary

The organisational analogies project reviews research literature and other interesting ideas on the relationship between organisational structures and behaviour and other physical, chemical and biological systems. Five types of analogies were explored, and different ideas proposed from each set of comparisons. In each case, the explorations made were intended to be stimulating and interesting, rather than rigorous.

From analogies to self-organising thermodynamic systems, lessons emerged on the tendency to greater complexity of such structures, and efforts were made to derive equations of state for companies which would allow the possibility of phase changes within them to more profitable states. The linkage to molecular chemistry is close, and on the basis of a mechanistic view of human behaviour, chemistry provides us with a strong analogy between organisational and molecular design, with human beings being viewed as atoms of different masses and properties, linked together by networks of responsibilities into complex solids with unique properties.

Evolution and biology provides a third approach, contradictory in several ways to those considered above. Research in the field has been widespread, but the implications of the central role of organisational survival not fully explored. Markets and organisations can be classified, and organisational strategies and their successes assessed from the perspective of long-term survival in different markets. The importance of rapid organisational change and of directed mutation within companies is emphasised as a means to address the growing change in social and technical environments.

Good analogies are found between companies and neural networks, and weaknesses of current organisational design from that perspective identified, such as the slow feedback process from the success of investments to individuals. Analogies with other human organisations such as markets and governments are also made, which provide minor perspectives on the benefits of internal markets and democratic procedures in social systems.

The overall conclusion from the report is that analogies exist, they are significant and useful, that suggestions can be made, but that the information required to be able to apply them prescriptively with any confidence is missing. The science of organisational design is at too early a stage to make the derivation of unambiguous recommendations appropriate. Whilst there may be right and wrong answers, we are many years away from knowing them.

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1. Background and Purpose

This is the report on the organisational analogies project, commissioned by N.G. McMullen and funded by UIC (UIC 6575). The project is based upon a proposed analogy between complex physical systems such as organic molecules, and complex organisations, focusing particularly on the thermodynamic properties of systems. This was extended to consider biological and ecological structures at the proposal stage. The goal was to identify whether there was any useful lesson to learn from such analogies about the structure and stability of organisations.

What are analogies for ? The major purpose is to identify limited symmetries between two systems, and then to draw lessons about the behaviour of the system to be predicted under other unknown states (predictive), or about how the system should be changed to improve its performance (normative). Some elements may already be obvious - the goal is to explore them further and to make them explicit.

From another perspective, the purpose of an analogy is to make explicit models held within people of how their organisation should or does function: in effect, to provide an extension to a shared mental model, facilitating communication and consensus decision-making. From this perspective it matters not whether the model is strictly **correct**: it is more important that it is **interesting** and **common**.

Analogies as such and thus strictly say **nothing** about the behaviour of a different system. However, humans have a natural tendency to analogise: it is one of the major methods by which people solve problems, and systems do share enough common characteristics to suggest there are some useful lessons to be learnt.

Our goal is to have a general influence on long-term planning - if one small analogical link is found to be of interest, with a feedback into organisational structures or policies, the project has achieved its goal, as the multiplier effect of all planning decisions is extremely large. This may occur as much via a "way of viewing" problems as via a specific technical recommendation.

2. Sources and Procedures

There were three sources for the ideas presented here: management articles and management theory, ideas and contributions by Shell staff from the planners forum and within IC, and ideas and analogies drawn primarily by the author. A number of references were uncovered, and recourse made to introductory textbooks in several subjects. The project is extremely wide-ranging, and it must be recognised that the "science" presented here is sometimes a little shaky. For analogical purposes, it will I hope suffice.

The project budget allocated was 10 man-days, to be carried out over the period 19 February - 20 March 1992 and the work was completed to specification, on budget and the draft report released on time. Many thanks are due to the staff of the Shell Centre

library, who were helpful in obtaining the numerous books and articles requested. Responsibility for all errors and omissions remains the author's.

3. Organisational Analogies - an Overall Assessment

The project brief was to look at analogies between the structures and properties of organisations, specifically profit-making companies such as the Shell Group, and physical, chemical and biological systems.

Examination of the literature which could be obtained in the period showed that interest in such analogies was already extensive, but focused on two main areas: analogies between company competition for survival in the marketplace and evolutionary competition between biological organisms, and analogies between organisations (of all kinds) and thermodynamic systems. In fact, in some articles the two approaches almost coincided. There was virtually nothing found drawing analogies between different properties of organisations and different molecular or atomic structures.

An important point to bear in mind throughout is that the value of drawing any analogy between a physical systems and a human system of any kind rests upon the essential orderliness, repeatability and predictability of human behaviour. Primitive behaviouralist theories of human response are no longer popular as psychological theories of human behaviour, but if analogies are to have any merit, it must be possible to treat individual humans at some level or other as predictable entities with predictable behaviour (even if only statistically). This remains a contentious issue. For the purposes of this project, it will be assumed (as do sociologists and others) that humans behave in a regular and predictable fashion, at least in groups.

A number of the texts examined paid particular interest to other types of organisation: urban systems, governments or voluntary institutions (see Appendix 1 for sources). During this report, whenever the term organisation is used it will be assumed to mean commercial companies unless otherwise stated.

Analogies between company organisation can be made from at least three perspectives, based on the granularity of the comparison:

- ✘ The first is the macro-level: to view an organisation as a single "homogeneous" entity in an entire human system, the aim being to predict properties of the whole system and suggest suitable behaviours for a single entity within it.

- ✘ The second is the intermediate level: to view the organisation as a collection of simpler structures, where the unit of granularity is the department or operating company, and the aim to predict the organisation's behaviour, and suggest suitable behaviours for the simpler structures.

- ✘ The third is the micro-level, where the analogy is drawn between individual people in a department and other entities, in order to predict departmental characteristics and suitable organisation and behaviours for individuals.

Sometimes the boundaries between the different analogies are quite narrow - there are

links between thermal physics analogies and molecular chemistry, and between thermodynamic views of systems and ecological theories.

Different analogical types conform to different methods of evaluating organisations. Gregory and Jackson grouped models into four classes:

1. Goal-based evaluation: the traditional view of organisations. This view is functionalist, that an organization is or should be designed like an efficient machine. It is found in thermodynamic analogies, chemistry and the "algorithmic" approach of section 7.

2. System resource-based evaluation, identifying the characteristics necessary for survival. This relates primarily to biological/ecological analogies.

3. Multi-actor-based evaluation, with evaluation based on stakeholders choosing their evaluation criteria. It is encapsulated in the phrase "For this type of system the idea of an account being meaningful has to replace the idea of any one account being correct." This is related to analogies with governments (see section 7), but is entirely contrary to analogies with evolutionary biology.

4. Culture-based evaluations, centred on the notion of obtaining commitment to norms.The aim of the evaluation is to produce more coherent and unified organization. This links with chemistry-based notions, but all analogies are in a sense intended to inform corporate culture. (Gregory and Jackson 1992)

4. Thermodynamic Systems - Analogies

Our first concern is with analogies to physical systems, specifically theories which are concerned with the thermodynamic properties of systems. This is a woolly and confused area, with a long history. There has been a lot of work done, applying the entropy law to organisations, and looking at open, far-from-equilibrium systems and the issues of self-organisation, but the practical value of much of it is questionable. 20th century social scientists have tended to avoid using physical science models because of their dehumanising effects in the past.

4.1 Early Approaches

The earliest analogies between organisation and physical systems were probably physical machines - the smoothly functioning company as a "well-oiled machine". This was the functionalist approach, a **goal-based** view which saw organisations as machines and management as rational entities dedicated to goal maximising. However, studies suggest that goals are not economically rational, and are often inconsistent or ambiguous, and that the machine is seldom designed specifically for the required purpose. In fact, one suspects that the analogy to a machine is closer to a "Heath Robinson" contraption which has been put together over a long time, with no overall design.

Cybernetics, "the science of control and communication" (Ashby 1956), attempted to deal with animal and machine states and behaviours in a connected fashion. It identified that systems have equilibria and invariant properties, and that different systems respond

to disturbances from equilibrium in different ways. Relations were identified between theories of information flow and energy exchange between systems. Cybernetics still exists as a discipline, but has tended to be renamed and incorporated into other ideas (such as system dynamics).

One result from this is that the more complex a regulator is relative to the item to be regulated, the better it will tend to do its job.

4.2 Open, Far from Equilibrium Systems

Whilst the detail is not wholly clear, there appears to have been a shift of emphasis in the early 1970s towards viewing human systems as "open", in which energy flows in and out, rather than the closed systems with which classical thermodynamics is primarily concerned. Several authors have treated societies thermodynamically as open systems, far from equilibrium, using information to process matter and energy in statistically describable ways. A hierarchical classification of systems emerged which had nine levels: frameworks, clockworks, control systems, open systems, blueprinted growth systems, internal image systems, symbol processing systems , multi-cephalous systems and systems of unspecified complexity. (Pondy and Mitroff 1979). There is significant dispute about the placement of human organisations as level 8 multi-cephalous systems, and in the process of analogical reasoning between organisations and closed control systems, open systems or "internal image" systems (such as animals). We will not consider this debate here.

In physics, **thermal equilibrium** is the state achieved by two or more systems, characterised by restricted values of their fundamental properties, after they have been in communication through a diathermic (energy transferring) wall. **Thermodynamic equilibrium** is the state where the system is thermally, mechanically and chemically in equilibrium (Zermansky and Dittman 1981). An **equilibrium** state is basically one in which the values of the fundamental variables do not change if external conditions are unchanged.

The second law of thermodynamics states that entropy increases in time until it reaches a maximum, when the system is in equilibrium. Thus the future becomes synonymous with increasing entropy and in the end with maximum disorder or chaos. Theorists have responded to this in several ways. Some claimed that to reduce entropy organisations should continually adjust their policies and structures. Others, such as Rifkin, used the entropy model to prophesy doom and destruction for the future, arguing that everything in human systems tends to chaos rather than to greater organisation. The main response, however, was to look at the properties of human systems and living systems in general, and to argue that this type of gradual degradation does not in fact occur (see for example Engelen 1988). Closed systems are closed to entropy transfer, and go from less to more probable states, open systems are open to energy transfer and go from less to more improbable states. The reason is that human systems are self-organising.

4.3 Autopoiesis

Autopoiesis theory (a completely unpronounceable term for a confused and faintly obvious theory) derives from exploration of the question of what distinguishes living

from non-living systems, and how they persist, despite changes in structure and components. An **autopoietic** organisation is a network of recurring interactions of production of components. It is self-organising, as it produces its own components. Maintenance of the autopoietic process is the overriding objective of the organisation. Such systems interact with environment to acquire inputs and dispose of waste products. A self-organising system must be a net importer from the environment, taking in more than it puts back (Amey 1979).

We see that animal and human systems such as companies tend to be self-sustaining, and respond to changes in external environment in order to maintain autopoiesis. There is some dispute about the theory's applicability to organisations as their components are not strictly self-generated. However, they do generate their own normative components, maintained by role-taking and the individual fitting into impersonal roles (Gregory and Jackson, 1992), and the use of money as an intermediate variable allows organisations to buy self-replication.

Autopoieticists have paid particular attention to biological systems, attempting to classify them, identify their boundaries and see how they are organised. We will return to views of organisations specifically as organisms in section 6. Apart from the lessons of biological systems, the approach gives us a conceptual framework, but little else specific. The only prescriptive view found came from Amey. He claimed that since businesses are not closed systems, they are not simple control systems, and the use of a single variable such as budget control is unlikely to help to maintain self-organisation and stability, which relies on controlling a number of variables, all of which are required for survival (Amey 1979).

Engelen's work on urban areas applies this approach to produce predictive results. His view was that all complex human systems evolve continuously and irreversibly. Evolution to a higher degree of complexity in a system far from equilibrium is the basic theme of self-organising systems. He used thermodynamic theories about systems behaviour in far-from-equilibrium states where strong flows of matter and energy traverse the system boundaries, to model large social systems using computer models (Engelen 1988).

4.4 Dissipative Structures

The concept of self-organising systems is closely linked to that of "dissipative structures". Engelen for example identifies in a chemical reaction that structures can appear which require flows of energy and matter to maintain them. These are dissipative structures. These do not have inert stability. When the system loses stability, there is a possible transformation to a completely new structure. These are bifurcation points, near which stable conditions become unstable, leading to fluctuations expanding and spreading to create a new state. This approach is apparently close to chaos/catastrophe theory - the study of the non-linear behaviour of systems in response to small perturbations.

Philippart takes very much the same interest from the viewpoint of sociology. He talks of an excess of entropy caused by the service sector and bureaucracy in a society. The basic claim is that to reduce entropy (wasted energy), an organisation should move

from a hierarchical to a non-linear system. This is a prescriptive (albeit obvious) point - that by reducing hierarchical levels you reduce energy waste. (Philippart 1987).

Amey and Engelen both link thermodynamic and biological analogies. Engelen claims that fluctuations in inputs are a vital force in evolutionary change. The evolutionary path is directional - structures build up "...a unique and irreversible history, and the structures that emerge build on preceding complexity and interactions." (Engelen 1988 p.55). This contradicts the work of people like Gould on the contingency of evolution. Gould stresses very strongly, using the Burgess shale as his example, the **contingency** of evolutionary paths, but denies the inevitability of progression towards greater **complexity**. Human systems may have an inevitable tendency towards greater complexity (Amey 1979). Biological structures do not. (Gould 1989)

The major lesson for the Group from all this are first, the **irreversibility of change** - there is no chance of returning to a previous state if a reorganisation goes wrong for example; and second the **inevitability of complexity**. Self-differentiation appears a fundamental process amongst all mammals. People will always organise to differentiate themselves, and create structures which maintain this (in addition to their ostensible control functions). These take more and more energy to maintain over time, until they become "uneconomic". Regular clean-ups every decade or so appear an inevitable part of organisations. These are "cusps" or bifurcation points.

One thesis which appears plausible today is that social and economic structures are becoming so complex that the self-organising structures which maintain the whole international economy and social system are becoming less stable. The overall system is approaching a point where chaotic change may occur at the macro level. This viewpoint is held by Handy: "Change is not what it used to be". (Handy 1990, p.4) In fact, as well as increasing and permitting increased overall complexity, computerisation may accelerate this trend towards dissipative behaviour, as computer systems tend to degrade non-linearly in adverse circumstances, unlike humans. Thus step-changes in problems may have non-linearly disruptive effects.

One interesting point is that discount rates reflect our inability to predict the future accurately. Since according to virtually everyone the future is changing faster, and in non-linear ways, discount rates should continually rise.

4.5 Back To Basics

An examination of standard textbooks on thermodynamics uncovers some interesting analogies, some of which have been explored in the literature above. What is done here is rather more speculative, which is to start again with basic thermodynamic textbooks and attempt to see if anything interesting can be derived about the essence of organisations. This section focuses almost entirely upon perfect substances, ignoring the implications at this stage of different types of materials or people.

4.6 Macroscopic and Microscopic Descriptions

The first obvious analogy is between macroscopic and microscopic descriptions of behaviour in physics and organisations. A **macroscopic** description in physics consists

of a few fundamental measurable properties of a system, suggested more or less directly by our senses. In an organisation, the measurable properties would be things like the number of staff, their profitability, the volume of resources they use, the volume of products they produce and their internal structure. These are the measurable properties of organisations which remain whatever the theory underlying them, which are " as sure as our senses" (Zermansky and Dittmann 1981, p.5)

However, as with physics, the macroscopic description is really an average over time of a large number of **microscopic** characteristics. For example, income and expenditure are the sum of all the individual expenditures of and on individuals and the income generated by them. The **statistical mechanics** analogy suggests that systems such as organizations are composed of individuals, each with states and energies, which interact with each other. To predict the behaviour or properties of the individual entities requires complex theories about individual behaviour, as well as collective ideas on organisational structures and function. The analogy suggests that collectives are predictable but individual behaviour requires a probabilistic model. What this tells us is that we do not yet have good theories of statistical mechanics for human societies.

4.7 The Problem of the Energetic Particles

Shell loses people who do not fit into the corporate culture. "Our organisation does indeed seem to accommodate with great difficulty those able people whose energies make it difficult to be absorbed into a steady organised team effort". (M. Church, Planners Forum 1992). The general view is that this does not really matter, as the loss of remarkable people does not seem to have led to errors in strategy, and most major decisions are consensus decisions anyway. In thermodynamic terms, these are the people (particles) with enough energy to break out of the organisation i.e. they reach the surface, then have sufficient energy to leave. It does imply that the overall energy level of the company is reduced by their loss.

4.8 Equations of Organisations

The boundaries of a human organisation, both within it and between it and the outside world, are "diathermic" (open to energy exchange) rather than adiabatic (closed). Thus we cannot strictly derive anything about the states of a company using equilibrium theory in thermodynamics. We can however see how the ascription of thermodynamic **properties** to an organisation would look. It is not possible to ascribe thermal properties to collective non-equilibrium states, but we can ascribe such properties to individual components of a non-equilibrium system. In fact, we can develop some interesting results. It is not clear at present whether any of this is of any value, but what is interesting is that it is possible to derive observed facts about human organisation, at a high level, from such a low-level physical theory.

If an organisation is to be treated as a thermodynamic system (even if far from equilibrium) it should still have thermodynamic characteristics. Having cast around a little for analogies of thermal properties in organisations, the following suggestion is made.

Thermodynamics	Organisational Thermodynamics
composition	organisational elements and structure
volume	size of organisation
pressure	income/expenditure ratio (profitability)
temperature	outputs/inputs (net work done)

The average rate of change of momentum in a unit of area becomes the average profitability. Net work is the overall ratio of outputs to inputs (less than one, according to self-organising systems theory).

If a given organisation is viewed as a thermodynamic system, it must have an equation of state, relating the three variables to each other. For example, with volume and temperature set, pressure is determined. Every thermodynamic system has its own equation of state, empirically determined. Does this apply in human systems ? In fact, the analogy strictly breaks down immediately, as these equations of state apply to **closed** systems - if we close the organisation off from its suppliers, it will no longer have these properties at all. However effort was applied to explore the analogy a little further, since despite its strict lack of thermodynamic basis, there did appear to be something of interest.

For a specific substance, the equations would be:

Profitability = f(Activity,Size) (and vice versa)

This is not strictly an equilibrium state equation, but rather refers to different potential states of a system at different energy levels, all unstable and including the interactions with the environment as part of the fundamental equations.

Increasing the net work increases the profitability. Holding size and activity constant, we should be able to predict the income/expenditure ratio and vice versa. This does not hold, as units of work done have different value. i.e. the energy quanta being transferred have different values in different environments. If the value of a unit of work was constant, the profitability would relate directly to the amount of activity carried out. As long as size (in some abstract measurement) is constant, the expenditure element is effectively constant, and hence this relationship holds, as income increases with work done.

Investment then becomes an increase to the net profitability (excess of income over expenditure in a period). This allows (rather than compels) an organisation to expand or to do more work.

Another thought is that as net activity declines to zero, individual molecules (people) have still some finite energy - the zero point energy, which is probably equivalent to their interacting purely with themselves. You can never remove the need to do something ...

What does all this tell us ? The first thing is that we do not have standard tools by

which to measure organisational properties, save for size. We have forms of profitability level measurement, but in terms of measuring work done or describing an organisational structure, we do not have standard libraries of structure or materials.

It suggests that equations of state could exist for organisations, to be empirically determined. The notion that the amount of money you make is a function of the work you do per unit and the size of the organisation is intuitively plausible, although the relationship is not really applicable to a single organisation, since the irreversibility of change shows that predicting change requires consideration of the stabilising effects of existing structures. Finally, it allows us to consider the concept of phase changes.

4.9 Phase Changes

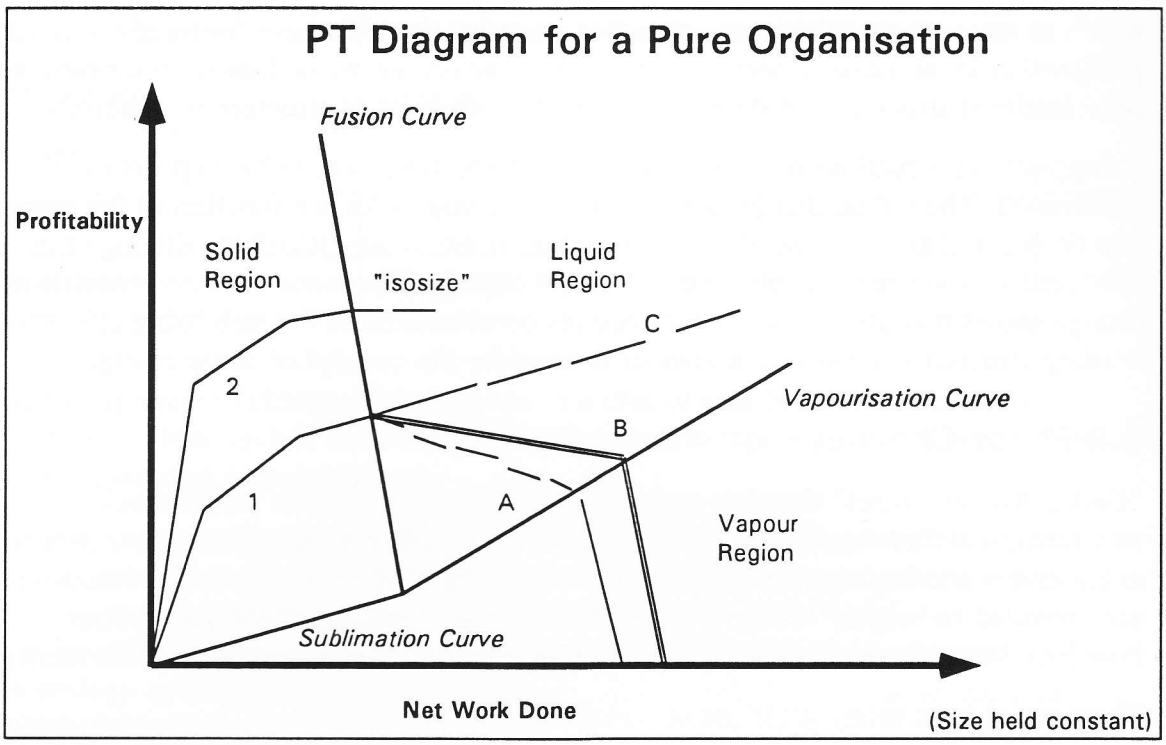
"Dissipative structures" theorists suggest that socially, revolutions produce new structures, and therefore are phase changes which significantly alter behaviour patterns, qualitatively altering organisations and increasing the efficiency with which resources are exploited (Artrigoni 1987). Whilst this itself is extremely contentious, it does introduce the concept of phase changes in organisations, which may have some merit.

There are at least seven questions of interest:

1. Are there analogies between organisational structures and the solid liquid and gaseous phases which are found in physics ? For this analogy, it is suggested that the answer is "yes".

2. Are organisations solids ? Exploring the analogy, most are, since they tend to have a regular structure, and individuals tend to operate within relatively tightly defined arenas and communicate with specified individuals. Organisations tend to be hierarchies, but this is disregarded at present since we are considering the principle of a perfect, internally undifferentiated substance.

3. Can we get more work done by converting one into another, and what is the optimal size of organisation to maximise (say) overall profitability ? A pleasant conceit is that "solid-phase" organisations could become far more profitable via, for example, increasing the "temperature" at which they work or by altering their size. A PT (pressure temperature) diagram for a pure organisation would look like the following, by analogy with thermal physics:



The very notion of having such equations and curves is of course faintly heretical. Still, it has implications:

a. That human organisations have explored only a tiny part of the overall states of organisations physically feasible.

b. That increasing the net work done of an organisation of a constant size increases profit up to a certain point (the fusion curve).

c. That continuing to increase work done for constant size will lead to a discontinuous change. It is not clear at this stage what happens in our analogy - do liquid organisations continue to become more profitable or not. It may depend on their size i.e. very large liquid organisations may not, but smaller ones may. The different possibilities are represented by lines A, B, and C for organisation size 1.

d. What happens at the vapourisation curve point? The final corollary is that requiring too much net work from a set substance of set size will lead to a discontinuous change at which profit will tumble, as people simply become unable to cope. This appears a realistic prediction. Theoretically, the diagram also predicts that for some sizes and substances, this drop-off will not occur (isosize 2).

e. Investment of money can spontaneously cause a phase change in a group from solid to liquid. Individuals would tend to become more autonomous.

f. **Sublimation** occurs when you require more work of a small (or large) enough solid. Rather than do more, individuals will "vaporise" i.e. depart. The latent heat of sublimation then tends to cool the material (reduce the net work done), and this will take it onto a new point on the profitability curve (probably lower).

4. Do we have examples of organisations or organisational groups in other phases ? A possible suggestion is that a consultancy group of equals (such as SMAB) in effect is in a liquid phase. There has been much discussion recently of the merits of unstructured and boundaryless organisations. These appear analogous to liquid groups.

5. What is the sequence of states in an organisation ? A plausible suggestion is that organisations tend to **begin** their life in a liquid phase. A small number of individuals perform highly-energetic functions, often interacting widely and exchanging positions, and adapting very quickly to their environment. After a while, there is a tendency to "condense" out around other, less energetic but more stable, individuals. Thus there seems, for example in the computing industry, a tendency for organisation to cool and solidify over time.

6. Organisations are not undifferentiated substances. Imagining an analogy with a series of layers of materials of different atomic structures (see below), organised so that the lower layers are connected to an external world, suggests for example that increasing the energy state of the composite will have a different effect on different types of staff.

7. Should organisations be hot or cold ? The answer to this question rather depends on one's perspective of the purpose of an organisation. The impression is that hotter organisations are more adaptable, less stable, whist cooler organisations are more structured (we shall come back to the tendency to hierarchical organisation in human systems later) and more inflexible.

4.10 Conclusions

This has been something of a roller-coaster ride through standard analogies with mechanical systems, with autopoietic self-organising systems and dissipative structures, and then onto some interesting but very speculative models of organisational structure. We have learnt that the main body of texts in this area give us a basic theoretical framework for thinking about systems, but tell us very little predictively or prescriptively about what we should do. From the group perspective, we see the reality of growing complexity and the need for discontinuous reorganisations. We also see the problems of controlling increasing complexity and the instability implied. The thermodynamic properties analogy probably tells us nothing new, except to suggest the potential of phase changes in organisations and to predict the existence of curves of profitability for a given organisation of a given size. Finally, we see the need for a statistical mechanics of human behaviour.

We now go on to look at these problems from two new levels: the chemistry of organisations, and organisational biology.

5. Chemical Analogies

Analogies between the chemical structures of molecules and structures and human systems in the management field have been few if any, and this section is based on the views of the author from using introductory textbooks on chemistry (particularly Ramsden 1990). In fact, lots of interesting analogies do exist, and may have explanatory value, but rest upon very mechanistic view of human nature, and require much further exploration before useful recommendations for action can be provided.

5.1 The General Analogy - Organisational Design

All chemical analogies share some common properties. The most important is that analogies to the world of molecular design are fruitful. Tools allow chemists to determine why certain molecular structures have certain properties, and design molecules which will be more active and selective. Why cannot we do the same with organisations ? We have no records or databases of standard organisational structures and their properties, and no standard tools to investigate internal structure and properties. It is not that they do not have such standard properties, or there would be no science of organisation design - it is rather that we have no agreed language or common understanding.

The big question is: is it possible to identify certain classes of human being, and do they react in similar ways when faced with similar circumstances ? The view of sociologists is essential that it is (at least collectively). If different individuals have different personalities (introvert/extrovert or whatever) and skills (physicist, chemist, politician, manager), this is analogous to different properties of atoms or molecules. Since recruitment is meaningful, and is directed towards filling posts and obtaining individuals with certain skills and attitudes, the implication is that implicit work-group design is already taking place. It has tended to be done via semi-random processes, and occasionally finding good combinations and holding onto them (just as it was in chemistry). Organisational design becomes "trying to use our knowledge of how the individuals and their roles fit together to understand the structure's behaviour and thence design a better one." (adapted from Fish 1989). Whilst chemists are molecular engineers, management planners should perhaps be organisational engineers - designing workgroups to meet needs, rather than letting them grow naturally.

5.2 People as Molecules

Perhaps the most obvious analogy is between people, as complexes of experiences, preferences and abilities, and entire complex molecular structures (ketones, amino acids). However, the implication is that you should be able to alter the properties of individuals via chemical reactions, and design new ones. This is not seen as particularly relevant, and it is believed that by viewing people as the irreducible (though occasionally modifiable) units of design, more interesting analogies emerge.

5.3 The Nuclear State

Another option is the analogy between departments and atomic nuclei. Individuals are then analogous to protons and neutrons, collectively building a department, which interacts in various ways with other departments and, when combined with other collectives, forms a solid, liquid or gas corresponding to the organisation itself.

We do not have an obvious analogy between different personality types and protons and neutrons, unless we divide people into "charged" and "uncharged" (essentially passive) people. The analogy would then suggest that adding or deleting neutron staff is a process of producing a different isotope of the same structure, whilst adding or removing "protonic" staff (a nuclear reaction) produces a completely new element. It also implies you cannot convert neutrons into protons, and that whilst neutrons add weight, they do not contribute to essential nature. However, they are required for stability.

At the end of the day however, the analogy is weak, because of the difficulty of splitting the atom (altering the staffing of a group), and the absence of support it provides for differentiation between types of people.

5.4 Individuals as Atoms

The closest analogies occur between individuals and atomic nuclei. Different nuclei have different atomic weights, with different propensities to take on and carry out responsibilities. They have different properties when combined into compounds and different preferred arrangements in space. They react at different temperatures, and have different propensities to bond with other atoms. Essentially, in the absence of an accepted theory, they have very much the unpredictability (number of types of molecule, behaviours, states, compounds) as people. They are of the same order of complexity.

In chemistry, structures are held together by bonds, particularly **covalent** bonds - a linkage between a particular pair of atoms, due to sharing pairs of electrons. Other types of linkage are **ionic** or electrovalent (an electrostatic attraction between positive and negatively charged ions). Stretching the analogy slightly, if people are nuclei, what is the analogy of the electron ? These are the basic units of charge. There are two options.

The preferred choice is to see electrons as technical responsibilities (for example projects). Where the same responsibilities are shared by several individuals, we have covalent bonds. Some links are polar (where bonded covalent atoms differ in ability to attract binding electrons - or the charge distribution tends to prefer one atom over the other). This is analogous to responsibility and work resting primarily with one individual over another.

An alternative is simply to view the individual as the entire atom, nuclei and electrons, and to view ions as people with certain things added to or missing from their personality, knowledge and skills.

In either case, elements are divided into atomic groups with related properties: the

noble gases (unreactive, with a full outer shell of electrons) alkali metals, halogens, alkali earths etc. There are stable configurations for electrons (responsibilities, skills) for each element (person).

Molecular symmetry is a central principle of chemistry; "certain parts of it can be interchanged with others without altering either the identity or the orientation of the molecule." (Cotton and Wilkinson 1972 p.4). This would imply that different people of the same atomic weight, i.e. "essential nature", can switch over jobs (take over each others' responsibilities) without changing the structure, but you cannot change the individual holding management responsibilities without changing the properties of the molecule resulting. Ionic structures are brittle however - they will crack rather than deform.

Alternatively, viewing individuals as the entire atom, we have positively and negatively charged individuals (optimists and pessimists ?), implying that the most stable state is one which brings these two together, and separates people of the same views. "The best arrangement of ions in a structure, being the one with lowest energy, is that which allows the greatest number of contacts between oppositely charged ions without pushing together ions with the same charge." (Ramsden, 1990 P.113).

Bonding is a function of the tendency to give, receive and share electrons. Different people have a different tendency to give and receive responsibilities, or to pass on skills and experiences. To produce well-bonded groups, in our first analogy (electrons as responsibilities), this implies we should bring together people with slightly too many responsibilities and slightly too few.

Exceptional people are then atoms which don't bond well to the others. A lesson could be that only external inputs (heating, catalysts, solvents) or moving the individual into a new material will provide a better "bond".

5.5 Ionisation

Ionisation energies are the energies required for removal of each electron in turn from an atom. This becomes harder as you approach the nucleus. This maps well into the process of stripping an individual of his responsibilities (or core skills). People accept responsibilities or develop skills, and it is this which brings them together. Splitting them off takes effort, and causes instabilities.

5.6 Solids

By analogy, when in a solid state (a direct linkage to section 4), different types of staff should enter into different types of configuration, with different strengths, responses to stress and conductivity, depending on the forces at work within the solid. Chemists identify several classes of solid, including metals, ionic compounds, molecular solids, macro-molecular structures, layer structures, chains and glasses. Macro-molecular structures are analogous to large groups with no internal differentiation. They are extremely strong. Metals are similarly strong because their responsibilities (electrons) become delocalised (shared amongst everyone).

From this perspective, we can see that individual consultants in a consultancy group are

"ionic" - they are brought together by electrovalent charges, into groups, but do not share electrons (responsibilities).

Different compounds require different heats for formation, and there are many influences on this. The implication is that different types of individual will combine together more or less easily, and that their electron states (responsibilities, skills) will influence this also.

5.7 Strength of Materials and Speed of Reactions

There appears to be an emphasis on homogeneity within Shell. This may strengthen the group as a whole (depending on the elements combined). However, adding impurities (alloys) gives metals such as aluminium a higher tensile strength and changes their melting point. It all depends upon what one thinks Shell is constructed from. Internal promotion leads to greater homogeneity, a more cohesive, communicative and integrated group but fewer ideas are generated and individuals' views tend to become self-reinforcing. By introducing impurities, you may weaken the structure, but may introduce new properties and speed its ability to change. "Doping" substances gives them entirely new properties.

A useful analogy is that fewer job grades implies fewer boundaries between materials, and therefore probably a stronger composite material. Some have also noted an analogy between plastic and metal organisations, with the implication that "plastic" organisations are more adaptable (Sparrow on Hammer, Planners Newsletter No.12 Feb 1991).

The term "catalyst" is also a common management phrase. Catalysts alter the rate of chemical reactions between different molecules - groups of individuals or individuals - without themselves being changed. Chemistry suggests that different types of compounds will have a different propensity to be catalysed. Physical chemistry indicates that catalytic reactions are speeded by increased temperature ("putting on the pressure", or requiring more work). Catalysts may have no other function.

5.8 Networking

One of the inspirations for the view of organisation as composed of molecular structures is the view of problem-solving as networking. Thus, small groups of people joining together to create a network of interactions is analogous to biochemistry of the body i.e. molecules breaking apart, joining up, knitting together structures on need. Individuals are analogous to complex molecules (as in 5.2), and serve functions within the whole organism. However, there are problems with this approach. Networks built on demand are a good way of managing certain specific types of project, where the specification of function is clear and the required model unambiguous. However, they are viewed by some as poor ways of deciding what projects to do, leading to loss of internal cohesion and direction, and tending to deskill in the long-term. The lesson from exploring our analogies here is that you can have network organisations, but they are atomic not molecular, and you need permanent designers to maintain personnel, planning and structural control, to design the components and their structures.

5.9 The Primordial Soup

From a chemical perspective, we could see the situation over the past few decades as an experiment, with a "primordial soup" of different complex molecules (amino acids ?) in a vat (the world economy) which are continually breaking down and reforming, and reacting with each other under the influence of inputs of energy (raw materials, social changes). The question then is : have we yet seen the emergence of true organisational life ? Perhaps so - all economic organisation seem to be structured in the same fundamental way. This says nothing about the validity of other models of organisations, except that the majority will be "unliving" - non-reproducing. Businesses built without the concept of interest, for example, seem fundamentally difficult to maintain. We will now go on to explore some of these issues in more detail.

5.10 Conclusions

At this stage, it is not considered appropriate to go any further with this: it needs a model of human nature(s) and a theory of chemistry which defines and records the properties of the resulting substances. It entirely depends on what one is combining, and as yet we have little idea of the elements or their properties. However, there is enough in this to suggest that (if one accepts any form of "mechanistic" theory of individuals), constructing a periodic table of people could provide some insight into their behaviour, and allow the construction of groups with different, and possibly entirely new, properties.

A positive point is that the thermodynamic analogy and the chemistry analogies match up quite well, upon examination, since the linkage between the statistical mechanics level and individuals as atoms looks strong.

Another obvious conclusion is that there are thousands of different possible organisational types, built from many types of people, very few of which have yet been explored. Some are more reactive than others, some stronger (e,g,. by delocalising responsibilities). Some are built from elements found rarely in nature (the very massive elements). They can be manufactured, but it is a very wasteful process, and many decay very quickly. It also implies that every type of person has some useful role. Every atom has a function to chemists, whether as a building block or an inert "shield".

The underlying concept of the model is that of the designer - the notion that organisations have rational or semi-rational purposes and that someone can model and construct elements in such a way as to further those purposes. What this document takes no view on is whether the entire notion is ethically desirable - "what a brave new world that has such people in it...". We now go on to consider a view which is diametrically opposed to this...the view of organisations as self-organising, and indeed living, systems.

6. Biological and Ecological Analogies

6.1 Introduction

Biology and ecology are probably the strongest and most useful sources of analogies to company behaviour. The area has been well-explored in research literature, and will continue to be of interest as a strategic research area (Lyles 1990). It can be examined from two perspectives: that of an organisation as an organism in a changing environment (within an ecosystem), and that which looks at organisations and their strategies from a long-term evolutionary view. We shall intertwine the two, since it is the central principle of this section that consideration of one implies the other.

Evolutionary metaphors are found everywhere in business. For example, "... only the strongest players in each segment of the industry will survive." (Vogtlander 1991 p.2), whilst all aspects of business planning such as re-engineering and competitive positioning are aspects of "..the same evolutionary process" (K.v.d. Heijden Planners Forum No.15 Nov 1991). Analogies with complex biological systems, specifically naturally hierarchical ecosystems, are often made, and there appear similarities at every level. Companies are bound together in an evolving ecosystem, based on energy exchanges, where an ecosystem is "any set of evolving interacting entities operating within a framework of rules".

Organisational ecology and strategic choice are competing perspectives on the selection and success of organisational strategies, i.e. is organisational life determined by environmental conditions or is it actively created through strategic managerial choice ? Organisational ecologists are environmental determinists - environmental pressures determine successful organisational form, function and strategy. Managerial choice supporters believe organisations manipulate their environment (Zammuto 1988). This report focuses upon environmental determinism, on the basis that a propensity to be able to take and implement strategic decisions is itself an environmentally determined ability.

6.2 Are Companies Alive ? Organisations and Organisms

The first question which must be addressed, if biological analogies are to be applied as thoroughly as desired, is: are organisations effectively alive ? They are mobile, irritable, they reproduce and excrete. They are not strictly autopoeitic, since they do not create their own means for self-construction directly (i.e. people), but via mental models and a mediating construct, money, they do self-organise.

The basic thesis proposed here is that organisations are directly analogous to living organisms - entities with an objective of survival. They are not necessarily rational or goal-oriented, any more than any other living entity. Like an organism's genetic code, the company has a structure and functions encoded by the past - through shared beliefs and management structures and practices. Individuals are cells in a body, organised into functional units. They are nurtured, live and die. Entire set of cells can be replaced, yet

the self-organising principle and personal identity is retained. The major production sites, for example, are seen as the "guts" of the firm (excreting products and probably people also), the senior management as the brain, personnel as repair and renewal, and security as white blood cells. This analogy is powerful and convincing.

Two other suggestions also provide useful ideas. One is the organisation as a plant rather than an animal. It has a core business and structure, with a distributed root system and leaves, based around a home territory (although some plants are "adventitious"). It expands and contracts, but can only move very slowly over time. Alternatively, some large companies such as Shell can be seen as analogous to a bee-hive. Decisions are taken by consensus, based on shared models of the world, in contrast to the "spiders web" model adopted by other companies. In-built principles based in instinctive behaviour maintain production, consumption and nurturing relations. The colony itself is probably then not strictly alive, but the individuals' roles are entirely defined, as a consequence of evolutionary adaptation over tens of millenia, to cooperative action for mutual benefit, and reproduction is focused on a single individual. This is in tune with Shell's policy towards individuals - that no-one is indispensable. Job rotation tends to support and confirm this approach. The problem with this analogy is that hive minds are almost entirely instinctive, and have changed little over millenia. This is not an adaptable form. A positive thought is that there is no direct analogy to the single queen in Shell - there are several - but a disturbing similarity is that "fast-tracking" individuals looks like feeding larvae with royal jelly...

In both cases, we see the organism as a whole as willing to sacrifice elements for its own survival. However, the hive analogy is rather weaker in humans, due to their greater instinctive sense of self-preservation, even in an economic context. Whilst wishing to ensure the company survives, people will be even more careful to ensure their own job survives. There are not many cases of people voluntarily sacrificing their jobs when they feel they are no longer cost-effective.

6.3 The Will To Survive

The crucial principle which emerges from examination of evolutionary literature and its application to organisations is the importance of organisational survival. The argument presented here goes beyond that in other sources: that organisational survival is not a rational, but an "instinctive", response.

If the competitive environment is seen as an ecosystem, then the "goal" of the organism is survival. There are two reasons. First, although this may never be explicit, natural selection will favour structures and processes which enhance survival. Structures have been selected for, if they were survival-related. Paying staff on time, having a chief executive, and functional differentiation have all been selected for over the centuries since the first economic agglomerations of functionally undifferentiated individuals arose. Second, people are socialised to support their organisation's existence. It is a rare event indeed for an organisation to liquidate itself voluntarily because more money could be made elsewhere. An example of the implicit model of long-term survival as the goal is Church's comment - "Companies have to plan so that they can survive and grow under all sensibly imaginable circumstances - that is part of their responsibility to

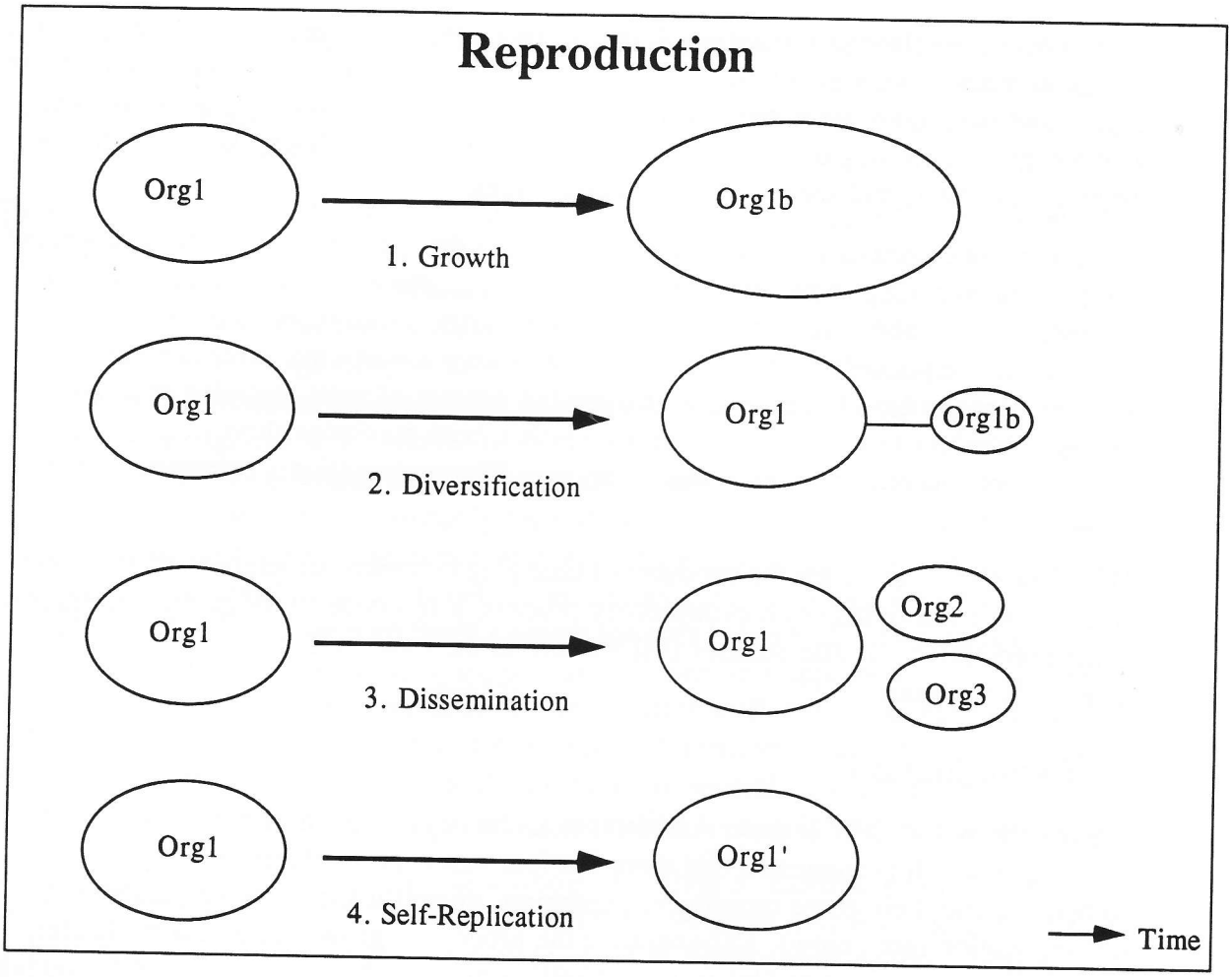
shareholders, employees and society." (M. Church, Planners Forum 1992). Why ? A company not surviving is not necessarily a loss to shareholders, if they can realise their capital and can invest more profitably elsewhere. It is not necessarily a boon to society, as the organisation may be positively damaging overall. It is relevant above all to the organisation itself, and specifically to its employees.

There is great emphasis in the financial world upon different financial measurements of company profitability as indices of success. However, these are seen by this model to be mediating variables, not final ones. They are partial measurements of success in survival. These are only essential insofar as they keep the external environment happy with the organisation. Exceptions to this are the process of asset-stripping and that of "going public". These are both strategies which aim to maximise short term returns, and have less interest in organisational survival. The organisation's behaviour is very different.

This view allows us to see the products of changing company structures, management practices and responses as an evolutionary process, a response to competitive pressures in the marketplace. It also stresses that looking to the long-term is what company survival is all about.

6.4 Reproduction

Organisations and their abstract structures must be capable of reproduction if evolution is taking place. It is suggested that there are four (asexual) methods by which companies and their genes reproduce: expansion, diversification, dissemination and self-replication (see below). **Expansion** is the process of growth into new territories, developing new regions or OpCos or just selling more in the same market and growing to support it. **Diversification** is entering new markets (spinning off subsidiaries or departments with a similar genetic code to deal with new products). **Dissemination** is more complex. It involves the transmission of genes via staff leaving and founding new companies using elements from their experience, and via companies publishing their successes in such a way that other can emulate them. The final and most important method is almost unique to organisations: **annual self-reproduction.**



Since there is usually only one identical example, the most important method of reproduction for organisations is self-replication - the annual process of reporting, assessment and continuation (or not). The entity derived annually is sometimes identical to the original (as with an amoeba). However, there are often slight modifications. External technical innovation and experience has an impact on the nature of the beast emerging.

A recent question raised in the Shell Planners Forum is the issue of selection for long-term survival over short term. The later an organism reproduces, the more time there is for possibly deleterious genetic dispositions to take effect. Organisms that reproduce later are therefore longer-lived, and this may apply to companies also. If you spawn new businesses early in your corporate life, the analogy suggests this perpetuates short business lifetimes by not revealing problems which might exist and emerge later. For at least two reproductive types: growth and diversification, this seems quite plausible.

6.5 The Evolutionary Model: Limitations

The evolutionary model of the company as an organism seems a close analogy, but has some limitations:

1. There is no real genetic code in a company. In biology, each cell contains the

blueprint for the whole. This is not so in organisations. The analogy is with the company structure and organisation, and with shared mental models (organisational culture). Genes are plans or ideas for structures and methods.

2. There is greater intentional behaviour amongst "cells" (individuals).

3. The organisation can respond to environmental change far more quickly and in a more directed fashion than an organism or even a population. An example of rapid adaptation is the move to unleaded fuel - a coadaptive response down supply/demand chains (see below).

4. Individual cells (people) come and go, rather than the molecules within them.

5. The boundaries of organisations are rather more vague than those of organisms, and can change more often (but then see for example corals and other colony organisms).

6. Institutional barriers to entry (standards, financial restrictions) found in many markets do not have a direct analogy in the biological sphere, unless it is specific evolutionary adaptations to deal with "indigestible" substances.

Given the quite different "biochemical" constituents of the two however, the models remain extraordinarily close.

6.6 Evolutionary Strategies

Evolutionary strategies are inferred from current behaviour and physical structure. We can similarly infer such views from examination of company structures. Organisms adopt an extraordinary diversity of responses to evolutionary pressure, and some have analogies in organisations. "The concept of strategy in organisational ecology focuses on how organisations within a population exploit resource opportunities in a niche, and under what conditions environmental selection favours different exploitation strategies." (Zammuto 1987). As with real ecosystems, the evolution of survival strategies is immensely complex. Oscillations, mutual dependencies, arms races, imitation, piggybacking and many other approaches to survival coexist.

The ability to be "strong" (i.e. take food from others) is, for example, not the only means to survive difficult times. Evolutionary analogies suggest that the best-adapted organisations to deal with food shortages are either:

✘ Fat (with the reserves needed to see out lean times - an analogy to the very rich company).

✘ Adaptable i.e. entrepreneurial (they can migrate or exploit other food sources).

✘ Able to live on little (they have kept themselves small, possibly not able to exploit the available energy as rapidly as the fatter system, but able to live on less). The analog is with an organisation which has been kept under tight financial control.

✘ Specialised in niches which are not affected by shortages.

The "arms race" problem ,whereby predator and prey together evolve more formidable attack and defence mechanisms, remaining in a stable relationship, is also a common company process. This is the "hidden power" of the market - the continual pressure towards more for less. Cooperative and oligopolistic arrangements tend to reduce this. IT may tends to exacerbate it, as IT provides a way of gaining a competitive advantage in a new dimension of competition.

Organisations that have evolved to meet open, easy, profitable trading conditions will tend to become big and slow. They do not need to be efficient. An example could be American car companies. In the biological world, this is always a temporary phenomenon. Aggressive predators which have evolved to meet different market conditions of competition, which then encounter new, in their terms easier markets, can sweep them up extremely quickly. An example could be the influx of far eastern companies onto the world market. Whilst these have not been subject to "heavy" competition in the traditional sense, they have been subject to a different form of competition, within a regulated economy, and evolved a strategy which proved successful there. It also appears to be successful outside their "home" markets. Ecological theory suggests that they will triumph, unless he "defenders" adopt a new counter-strategy, but that eventually victory will be "phyrric", since conditions prevailing in the new markets are unlikely to provide the basis (in the long term) to support the same evolutionary strategy, unless the home environment can itself be replicated.

For some organisations, generalism has been their evolutionary adaptation. As with animals, they have preferred food sources (e.g. nice grasses first, acacia trees last), but are designed to be able to make money in a variety of markets. Others are very specialised e.g. hummingbirds adapted for one specific flower. This type of organisation, for example, is one devoted to supplying car spares for a particular factory, or support services for a given company. If that changes or closes down, its prospects for survival are bleak. By analogy, Shell is probably a specialised type of organism (it primarily produces energy), but one that has found an extraordinarily wide abundance of its food supply (demand for the same).

Examining oil and gas supply processing and distribution, we can see that there are evolutionarily several competitive responses to a gradually tightening position in supply, and rising costs of exploitation and decommissioning over the next 50 years:

1. Die (i.e. taken over, break up, bankruptcy).

2. Find a new resource which the existing organisms can mobilise (e..g alcohol production, methane).

3. Adapt over time to be able to use existing resources in new ways e.g. oil shale exploitation, enhanced recovery methods.

4. Invade another market (e.g. move into new countries).

5. Fight competitors for the remaining resources - in effect taking over and break up other oil majors.

The economic environment is rather more symbiotic than the evolutionary. Supplier

relationships between firms at different levels can be seen as symbiotic, cooperation for mutual benefit. At another level, however, they are merely energy chains, where each individual organism aims to maximise its own energy input and minimise its output. Joint ventures are the most obvious examples of symbiosis. However, where is the boundary organisationally between symbiosis and parasitism ? A classic case is the IBM-Microsoft relationship. Microsoft were the small symbiont providing additional facilities which IBM could not or did not want to do. The situation is now rather different. Where a large company such as Shell takes on symbionts, it must be very clear about the added value they provide. If they are growing faster than the host, the energy exchange is favouring them too much.

6.7 Organisational Structures and Business Reengineering

In this analogy, organisation structure must influence organisational behaviour. In fact, the two are often seen as closely related. The major concern then becomes which attributes contribute to organisational survival. There is a link here back to the viable systems model of Beer - defining the functions necessary for an organisation to have independent existence. Evolutionary theory proposes that structures evolve in response to competitive pressures over many generations. It would be surprising if they did not have behavioural implications .

Small organisations are a rapid means of evaluating market niches. If we view them as instances of a simple organisational structure (the small business adaptation), with different specialised energy sources, the genes for that organisation are being passed through individuals via word of mouth and mass media, until they fruit and a small business is born. As with simple organisms like bacteria, they are structurally very similar, and the majority will not survive, but those which strike upon a winning formula do well. They are, *en masse,* able to adapt far more quickly that larger, more complex, organisms. Smaller organisations, by virtue of being simpler, require fewer such support structures (a bacterium is then the equivalent of the self-employed person).

The top management of the firm is usually responsible for its structure and design. They rarely completely destroy to rebuild, but usually attempt evolutionary change. However, some systems are far more resistant to such change than others. Some systems seem designed to prevent the desire for new business processes ever arising. The suggestion here is that management strategic choice is to some extent analogous to intelligence - a facility which has emerged as sometimes beneficial, but in other circumstances not (as a look at the daily papers will suggest).

Considering the new hot topic of business reengineering, the implication from this model is that reengineering is critical to organisational survival - it changes the "genes" that will be passed on. Moving back to the thermodynamic analogy, it may be an inevitable response to the natural tendency of human systems towards greater complexity, but this is rather more controversial in biology.

What it also tells us is that in attempting to build, operate and maintain firms, we are trying to design extremely complex structures, which are stable, self-supporting, adaptable and so on. Evolution has been "doing" this for billions of years, and certain approaches have emerged as relatively successful (albeit contingently). Whilst the very

presence of some feature does not mean it should be emulated in social structures, it suggests that consideration should be given to some analogue of its functioning.

When following the maxim: "Don't automate: obliterate", the evolutionary paradigm suggests that we should be very careful to recognise why certain structures or processes are there. It suggests there are three reasons:

1. It is completely irrelevant - for example a human-generated support and differentiation structure. These may emerge again, but do not actually have any other function for the company than keeping the staff dissatisfied.

2. It is archaic. It used to have a purpose, but no longer. The classic example is the human appendix (perhaps Shell telex ?).

3. It is genuinely needed, often only occasionally. Removing these tends to weaken the ability of the organisation to respond to emergencies.

6.8 Adaptability as the Key to Survival

There has been much recent discussion about the rate of change in technology and in the environment. In 1955-80 238 companies disappeared from the Fortune 500 list. In 1985-89 143 did so (Velsen on Pascale, Planners Forum). One lesson is that fine tuning and optimisation in this kind of competitive environment risks **over-adaptation** - the organisation cannot respond to environmental change (Planners Newsletter No.12 Feb 1991).

One result has been an emphasis on expertise and innovation as the basis of competitive advantage, rather than a physical asset base. The generalist is more likely to succeed, and the faster organisations can change, the better their survival prospects. In the natural world, rapid adaptation is primarily the prerogative of small, rapidly reproducing, high-volume systems such as mosquitos. This has not been Shell's view or approach in the past, and it suggests some problems for the future. However, we also have in organisations an additional element, that of voluntary re-design (see below).

Another reason for greater confidence that large companies will do no worse than any others is the "punctuated equilibrium" theory. In effect, this suggests that change can sometimes occur so rapidly (as with the death of the dinosaurs 60 million years or so ago) that no organisms in an ecosystem can adapt, and that the survivors are almost random (the contingency of evolution).

Local adaptation in the organisation is another phenomenon of concern. By this view, Shell is a collection of closely linked but semi-independent structures. Different living entities adapt slightly to their environment, and as soon as populations become isolated to any extent, selection and accident will initiate "speciation" - the division of previously homogeneous group into different species. As with populations of grazing mammals or fish, over time, without cross-fertilisation the individual Shell companies will evolve into separate species and eventually will be unable to reproduce together. Pushing the analogy, this suggests that the lower the rate of exchange of staff in an OpCo, the more it will self-differentiate over time, and eventually it will be more of a problem than it is worth to switch staff back and forward at all.

6.9 Rational and Instinctive Organisational Behaviour

Amey suggests that in biological systems there are three classes of behaviour, with analogues in organisation:

1. **Reflex or instinctive**: the guiding principles shared by all firms, such as the general desire to survive financially and basic business principles.

2. **Learned stimulus-response (cybernetic)**: for example the budgetary control system. These are the element of management action which maintain states or seek predefined goals.

3. **Learned autonomous behaviour**, such as forecasting and strategic planning (Amey 1979).

The consensus management process found in large organisations such as the Shell Group becomes analogous to management by instinctive or learned cybernetic behaviour. Many argue that in fact it is this type of "emergent" learned/instinctive management which is most successful: "...companies respond to events in ways that can be explained in retrospect but cannot be foreseen." (Sparrow, Planners Forum, No.11 Nov 1990, p.4). Their decisions are based on intuition, feel, precedent and experience. "Gut feel" is the best response to rapid change (Planners Newsletter No. 10 Aug 1990). There is a view that such "management by consensus" is equivalent to management by drift, and that in very large companies this is the safest approach, as the multiplier effect of a decision can be enormous. Because all ripples represent long-term changes in direction, any such change can have a massive multiplier effect and change corporate direction unintentionally. This is rather like some sort of dinosaur analogy - the organisation is slow to learn and slow to change, but unstoppable when it gets going.

However, there is evidence that this approach will become less successful in the future. Active "intellectual" leadership, analogous to rational decision-making permits the possibility of autonomous (i.e. unprecedented) action. Simons suggests that innovative companies are the ones which use formal strategic approaches most intensely. This implies that the ability to innovate is linked with avoiding relying on experience of the past (Galer on Simons, SMS Conference 23/24 October 1991). If the ability to understanding and control the environment is related to intelligence, there must be some doubts how "intelligent" some organisations are, since they rely on instinct rather than intellect.

The biological analogy suggests that, as long as consistent conditions apply, emergent strategy will be the most efficient and successful method of management. However, in a situation of rapid change, the learned and inherited behaviour of the past becomes irrelevant and anachronistic. The increasing rate of change today implies that "intellectual" rather than instinctive behaviour will become more important in a company. This in turn implies a need for more head-office strategic decision-making staff, and probably more technology and research staff also. It emphasises the importance of access to information.

IT systems help mainly in increasing the efficiency of existing processes. Infrastructure

systems and applications tailored to company needs tend to be less useful in environments of rapid change, because IT systems change more slowly than people do. Applications can help people decide how to change, and identify new sources of energy, but they will always lag behind human decision-making. The implication is that you should automate support processes, but not automate core business processes.

Another implication of growing adaptability is that it makes long-range planning unnecessary. To remain viable and adaptive, businesses must be structurally and organisationally flexible. Amey suggests that adaptability should be monitored by management as a positive virtue. "The organisation must be fundamentally committed to impermanence." (Amey 1979 p.255) However, living organisms have never had to experience the rate of change now found in human environments (and indeed in the natural one...). To deal with this, companies have made use of special facilities.

6.10 Research and Development and Directed Mutation

If we examine the sources of change in an organisation, disregarding the identity of the individual cells or molecules, we will see growth, changed markets, new products and new processes. We will also see new management ideas and new organisations. The external environment is continually changing, and requires changing structures to cope with it. As we have seen, adaptability is crucial to survival. The aim of R&D is "...to provide a technology base which will give a company a commercial advantage over its competitors." (R&D in the Oil Industry p.1). R&D, combined with the extraction of lessons from experience by staff (organisational learning), is the basis for what must be described as directed mutation.

Directed mutation is the process of deliberately altering certain characteristics of your genetic code to meet new environmental pressures. This concept, long regarded as heresy (Lamarkism) has recently experienced something of a revival in biological circles. The fundamental principle of neo-Darwinism is that organisms evolve by a process of random genetic change and natural selection. Orthodox theory holds that spontaneous genetic change and the environment are independent variables. The environment selects mutations but cannot direct them. However, since 1988 a series of studies have shown that mutations seen in the bacterium are **not** always random, but appear to be a calculated response to environmental pressure. Rather than going for a sudden death assessment, experiments placed bacteria under sustained environmental pressure (e.g. they were unable to metabolise lactose). Rather than die they simply stopped growing. The bacteria mutated to be able to metabolise lactose at massively greater rates than random selection would suggest, and focused on changes specifically to the gene needed for this purpose. Where lactose was not present, bacteria did not mutate to metabolise it. These were resting cells, not growing ones, so the mutations were not the result of cell replication errors either (Symonds, 1991)

Applying this notion here, we see that, under increasingly tight competitive pressures, we would expect companies to increase their reorganisation rate, their new products and their R&D, to identify new products, markets and sources of energy in order to survive. This appears to be happening at present (Kantner, reported by Galer SMS Conference 23/24 October 1991). A simple comparison of Shell total R&D spending

the mayfly, which dies once it has reproduced).

Another sexual reproductive method is bringing new people into your organisation. This introduces new genes (organisational structures and management practices), therefore enhancing your progeny in future, if they are selected for within the company's operations. This is not strictly natural selection (since it involves overt action), but is important. By only taking its leaders from within, opportunities for organisational innovation are reduced.

Another interesting analogy is between sex-related characteristics and financial estimates (though again the "sexual" partner is different). Evolutionary pressures tend to favour indicators of good health, such as a glossy tail, in reproductive preferences. However, males and females of a species may become locked into a self-reinforcing cycle in this respect, with evolutionary pressure strongly favouring characteristics which are no longer primarily health indicators (as happened for example with the peacock's tail, which apart from its reproductive function, is a positive risk factor to the organism's survival). A similar thing may be happening with indicators of financial performance, such as P/E ratios and large investors. The medium is becoming the message, and financial attractiveness is more important that underlying health. The "dividend treadmill" is the result - companies cannot afford to become more healthy if they **look** less pretty. This process also occurs to some extent in IT and R&D in general. The "if they have it, then we must too, or we will be seen to be behind and therefore vulnerable" feeling exists here also. The tendency to "buy IBM" in the computing industry may also be seen as another case of "sex"-related characteristics. Large companies have adapted to deal with other large, stable companies which do not necessarily produce the best products.

6.13 Core Competences

There has been much discussion lately of core competences in an organisation i.e. defining and nurturing core businesses and skills, a response to the costs associated with diversification in the past. The analogy here is with the core functions of a body - maintaining body temperature, food and water, rather than concentrating on value-added services such as being comfortable and reproduction. Galer notes that today product offerings are being simplified, which is equivalent to eating only the most energy-profitable food to reduce energy loss from movement. (Galer, SMS Conference)

One implication of the evolutionary analogy is that "outsourcing" should never lead to contracting out core functions (and this includes temperature control, analogous to some basic IT functions). Eventually, some conflict will lead self-interest to take the two companies in another direction, and the company who relied on the other will be in mortal danger.

Another lesson is that more compact forms will survive cold weather better. An organism in a cold climate will sacrifice fingers and toes to keep core temperatures up. This is in effect what a company does in harsh times. Companies with longer chains of supply will suffer more.

6.14 Analogical Levels and the Self-Ascription Problem

Devolution and devolved units are an effective way to survive in diverse environments. However, as Shell is well aware, there is a price which must be paid for this. If we accept that there is a tendency for organisations to self-perpetuate, and that this is supported and reinforced by the self-interest of individuals, we can add to this that there is more than one level to which an individual can ascribe the group membership which will reinforce the "survival prospects" of the organisation: department, function, OpCo, group or even nation.

With devolved, differentiated or self-sustaining units, there will be an inevitable tendency for the "boundary of the organism" to be drawn over time more tightly round the unit, rather than the whole firm. The firm then becomes the market or resource to be exploited, and the department or OpCo itself the creature which aims to ensure its own survival. These organisms will then begin to complete internally for survival, and these will tend over generations to replicate (both directly and via emulation/imitation). If an organisational sub-structure benefits the group at its own loss (for example failing to cross-charge all its activities), it will die. There is thus competitive pressure to adapt and behave in a "selfish" fashion. This makes the structure the basic unit of survival.

The self-ascription unit drifts downwards over time if not arrested. The result is decision and actions which are in the interests of the survival of the unit, but not necessarily the whole firm. This may lead to the non-optimal allocation of resources.

The solution adopted by the Shell group seems twofold: shared goals, reinforced by personnel rotation.

6.15 Business Ethics

Ethics is the study of how we should behave - of morally correct or right behaviour. Recent interest in business ethics is particularly associated with environmental issues, and Shell has a particular interest in this. There appear to be four reasons for a company behaving "responsibly": certain actions are morally "right"; they are instinctive anyway; they promote long-term survival; and responsibility is cheaper anyway.

In business, from an evolutionary perspective these tend to cohere. If the long-term goal is survival, behaviour patterns will have evolved which have achieved this in the past. A classic example is the "slash-and-burn" approach to non-renewable energy resources. Since there was no loss associated with the use of resources, there was no selection strategy against it. Today, this is patently not the case. Since governments control the regulatory environment, and people influence governments, Shell can expect democracies to impose stricter controls over "unethical" practices as time goes on. This should be considered not as a problem but an opportunity - a normal part of the business environment, to which the group must adapt. Process refinements are also where organisations such as Shell are strong.

The other option of course, is to change the rules.

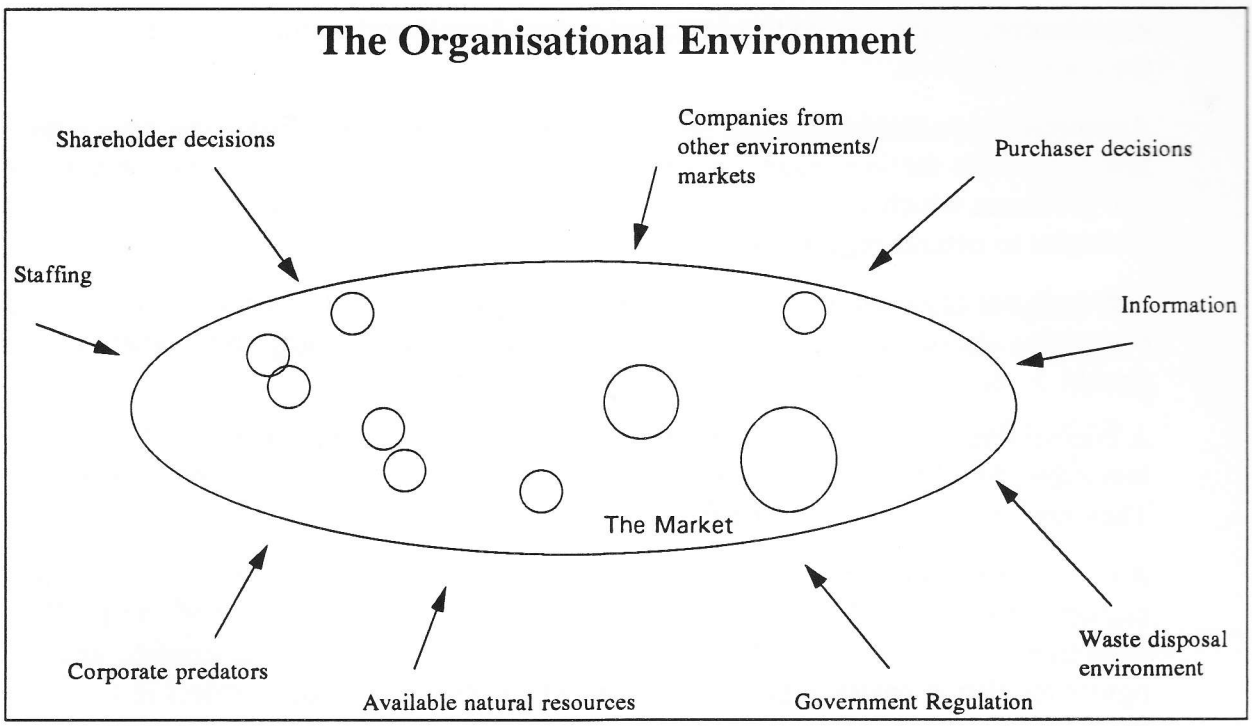
6.16 Cooperation and Oligopoly

Oligopolies such as the oil industry, where there are a few large structures competing directly in a fully-occupied "commoditised" market, are rather different from perfect competition environments. Analogies exist directly between these situations and ecological systems. The "perfect competition" environment is analogous to the resource behaviour of a worm - there are large number of relatively undifferentiated organisms, and the behaviour of a single organism will have no discernible effect upon anything, particularly the behaviour of other worms. An oligopoly is far more similar to a group of "top of the food chain" predators - the decisions individuals make directly affect the survival status of other predators.

Reddy and Rao's thesis is that in oligopolies, resource dependencies lead to formal arrangements that replace price as the mechanism of coordination of exchange. Markets are networks, because forces encourage it, and this is supported by networks of personal and organisational ties. The globalisation of markets has also increased interdependencies, for example through joint ventures and technology sharing. (Reddy and Rao 1990). Thus the process of symbiosis is broadening.

In situations where individual decisions affect overall resource allocation (i.e. the game is not zero-sum), cooperation is a natural and essentially inevitable response. Humans, lions and wolves have all evolved cooperative predatory strategies to maximise collective return. If the environment gives a replicative benefit to cooperation, then it will occur eventually. Another fact is that organisms have long affected their environment, generally very gradually (although humans have got very good at it very quickly). Changing the environment to suit yourself is a standard competitive response to adversity, ranging from otters using rocks to break open shells to termite mounds providing insects with protection.

Similarly, oligopolistic businesses will naturally and rationally attempt to influence their competitive environment (see representation below):



The organisation must attempt to solve a massively multi-variable optimisation problem where the evaluation functions are continually changing and the payoff strategies unknown in advance. One way to do this is to attempt to control some variables. Since many of these are set by government, a natural response is to attempt to influence government, and this is best done through collective action. The organisational response is to adapt where necessary (new tax laws etc), but to alter that environment if possible, particularly by collective action. This is the major function of lobbying, for example record manufacturers and CD producers lobbied US Congress to deter producers of DAT recorders.

The influence of big business over its environment may well be less than in the past - today the use of direct legislation to protect the interests of individual businesses is much rarer. The implication is that large companies, despite their oligopolistic actions, will have less control over their business environment, and hence their need for adaptation will be greater (Planners Forum No.9 May 1990).

6.17 Conclusions

This section has identified a number of symmetries between markets and ecosystems, and between companies and organisms. The majority have been descriptive rather than prescriptive. What the analogy shows above all is the value of thinking in this fashion about problems, and the fundamental importance of organisational survival.

There are other possible recommendations implied by the analogy, although many of them may be slightly dubious in practice. One important recommendation is that the ability to change markets, products, organisation and management is crucial for long-term survival today. The lessons of biology, extrapolated to the present, are that we have a system with the ability to alter its own genetic code selectively, and that the

organisations which can do this best, and indeed "steal" codes from elsewhere, will be the ones to survive.

Another point is that in business re-engineering processes, identified as necessary every few years from thermodynamic perspectives, it is important to identify **why** structures and processes which are non-optimal have evolved. To do this, it is useful to consider analogies to natural regulatory mechanisms.

Although not explored in detail, the plant analogy looks useful as a means to view large companies like Shell. As with molecular chemistry, it says nothing about what you **should** do until you decide what kind of plant you are.

A controversial suggestion is that for an oligopoly, cooperation is natural and inevitable, but that companies have less control than before over their environment. They need new instruments of control.

A related point is that Shell is a generalist in a process-optimising environment. In new market niches it will always lose out at first, but large companies are likely to gain from tighter regulatory restrictions. They are the process optimisation experts, and tighter regulation creates a barrier to entry. The inability to model barriers to entry in the model and the benefits of large scale production and competitive advantage more than outweigh the suggestion that henceforth "small is beautiful".

A somewhat surprising suggestion is that strategic decision-making at the centre will become more important, but long-range planning less so. Learnt behaviour is best in stable environments, but the faster change takes place in the world, the more "rational" action is required. Companies should monitor the rate of change of their environment and their own self-renewal. Finally, we see that competitive responses to stress are varied, and in organisms they do involve greater innovation. We expect the same in companies, but it is held back partly by the sexually-analogous need to appear attractive to investors.

7. Other Analogies

There are a number of other organisational analogies which can be drawn. Four are considered here.

7.1 Computer Programs

One of the more interesting is the analogy with computer programs. The original focus (a hard systems engineering approach) was on an organisation as a system obeying a sequential set of instructions. The ideas was that companies could be run by iteratively planning, evaluating, taking actions and then replanning. Adding a learning module allows the adjustment of goals. Objectives are ranked, alternatives evaluated and courses of action selected. This is a control systems analogy, the "algorithmic" approach, but it is not longer widely popular.

A second theory sees object-oriented programming as a model for self-organising systems. Each department or group is a "black box" with behaviours which are defined, but with structures which are local.

More recently, Shell staff such as Oliver Sparrow (UKAB) have become interested in analogies with neural networks. Neural nets are massively parallel, adaptive networks of simple processing units, which can recall information associatively from incomplete or noisy inputs, and can derive optimal mapping by generalisation from examples. They are based on idealised models of biological neurons, taking signals from units and producing a signal which can be passed on to others. Each neuron operates independently, and different network architectures are defined by different transfer functions, patterns and strength of interconnections.

This a useful analogy. The "instructions " for successful operation of the company are distributed amongst the processing elements (people), each individual solving a little part of the problem, with no one person seeing the whole problem. The output is a decision on any aspect of the Group's interests. There are hidden layers, neither input nor output, which help process information (or products). Different connections are weighted, corresponding to different people's personal or work-related contacts, through which views and advice pass on their way to the output layers (the final decision). Some are excitory, others inhibitory. Feedback also returns via the system to reward or punish those involved in decisions.

The learning process is crucial both for organisations and neural networks. Neural networks can learn in supervised or unsupervised modes. Learning in organisations is generally unsupervised, since no-one tells the organisation what was a good decision or a bad one in a simulation before it puts it into practice. There is a little supervised learning for individuals, provided by training services. In effect, these attempt to fit new neurons approximately into the system by setting the initial weights somewhere near what they will be required to be, or by adjusting weights off-line. Unsupervised learning requires an evaluation function, plus feedback mechanisms which allocate reinforcement to individual neurons which contributed to good decisions. The same risks of over-adaptation occur with neural as with biological (and organisational)

systems. Excessive specialisation becomes too constraining.

How useful an analogy is it ?

1. Neural networks are good at pattern recognition, classification and control functions. Their control functions are best carried out without a hidden layer (Croall 1991) - an interesting analogy, since it implies that a direct connection between data input and decisions output works best for control functions (which could include controlling a complex process.

2. No machine-learning designer would conceivably build a neural network with the kind of structures that companies have. If a neural network were designed with lots of hidden layers in a hierarchy within which some decisions were taken and other referred upwards, it would be very unlikely to learn. This relates to the note under thermodynamic systems that multiple layers waste energy.

3. The reward/punishment cycle is far too long. Staff may well have left (due to career moves) before the feedback from a given decision reaches them. Attempting to train a network where the neurons swap around throughout the process is almost impossible. Better feedback procedures are needed for staff performance.

4. Sometimes, the rewards don't go to the right things for example fixing problems rather than avoiding them in the first place, because the "evaluation function" (measurement of success) is too short-term. Whilst overall profitability may be a good Group-wide heuristic, the reinforcement methods for individual staff are not related to this, and tend to focus on criteria with other purposes, such as performance compared to colleagues, technical competence, and behaviour, which may well be unrelated to the overall objective, and tend to be very short-term.

5. The pattern of connectivity characterises the architecture of a network. In most commercial neural networks, the number of neurons is quite low, and the connectivity quite high. In the standard three-layered model (input layer, hidden layer, output layer), each input layer will be connected to each hidden layer neuron and each hidden layer to each output. In an organisation, most of the linkages which are potentially possible between individuals are never made. The actual linkages are very sparse.

If there is a lesson for company organisation from this, it is that groups should be more stable, that feedback on performance should be faster, and also that if exchanges of staff must take place for other reasons, then more of the shared memory should be retained by the job and less by the individual.

The other lesson is simply that no-one would build computer systems to perform efficiently with the overall structure and feedback processes that companies have. A neural net trying to learn without definite examples, when the environment is changing, the evaluation function for success is unclear and differs in the short and long-term, someone keeps swapping trained with untrained neurons, and where the feedback time is so slow that many neurons have been swapped before the feedback returns on any

final decision, is completely unrealistic. But then again, is efficient performance the primary goal ? As we have seen, some structures seem to be self-reinforcing evolutionarily.

In passing, Philippart points out that the analogies liked and adopted are a function of the period that people live through. Clearly computer systems are the analogy of today.

7.2 Organisational Memory and Learning

An analogy which is then inevitable is between an organisation's experience, the collective sum of its documents, learned behaviour, structure, databases, procedures and human memories, and the memory of a human being. This is related to biological analogies, as well as to neural networks. The problem is that companies must retain their information and decision-making abilities in a situation of continual staff rotation. As we have seen, staff rotation helps reduce speciation (diversification of different companies into independent groups) and keeps the self-ascription level of staff high. However, it also means organisational memory is weak, forgetful and inconsistent.

According to Wiersema, organisational preservation of knowledge, behaviours, norms and values over time makes it difficult to change (Wiersema 1992). In other words, ignorance also allows flexibility. In a rapidly changing environment, adaptability appears to be extremely important, but simultaneously growing complexity requires consideration of more issues before action.

The question whether organisations themselves have memory, or just the individuals in them, is contentious. The view proposed here is that they do, and that it is contained in shared cultural norms and organisational structure (intuitive knowledge and inherited behaviour), whilst the factual type of knowledge often discussed is contained in documents and individual people's heads. This links back to the differences between learned behaviour and instinctive behaviour discussed above. The neural network analogy suggests that organisations as a collective can learn, even though individual neurons do not understand why they do what they do.

The analogy also suggests that organisations which experience too rapid change in personnel will tend to suffer from Alzheimer's disease - an inability to retain information.

The question to what extent organisations learn and to what extent they evolve (i.e. adapt non-rationally as a consequence of selection processes) is interesting. Organisational design is a collective response to learnt organisational behaviour, the equivalent to genetic engineering. The molecular engineering theory suggests that people can design organisations to meet goals, based on collated shared experience. The evolutionary theory suggests that, if they are not based on previously successful models, one can say nothing about their survival characteristics.

7.3 Economies

The prevailing wisdom today is that command economies do not make the most rational economic decisions, and that the invisible hand of the market produces more nearly optimal allocations - "The market is the worst possible mechanism for regulating

choice, except for all of the others". It remains questionable to what extent this philosophy is applied within large industrial companies, most of which are organised as command economies, with centrally planned budgets at the start of the year, defining the production and supply relations between them. Whilst there has been a tendency within companies to devolve budget-holding downwards, the annual planning process still has no real analogy in the open market.

There was recent discussion in the planners forum about systems which had evolved a structure without real planning or management control (even in their setting-up). The characteristics identified were: little communication between individuals, actions taken in direct response to stimuli, delays, rework and waste of materials, with management "noticeable by its absence". However, it was also noticed that this appeared to have been overall quite successful. This is, in fact, the classic market mechanism. Whether it would work well in Shell is another question - there are not several independent E&P's. However, at a lower level there is competition in the market within the group - between in-house experts and head office, and amongst the proponents of different technical solutions to problems.

7.4 Managing Societies

Another issue relates to the running of societies by governments. Autocracy is unfashionable, and pressures are being placed upon governments world-wide to make decisions by democratic processes. Yet all companies are still run according to what could be seen as an "autocratic" or military model, with appointed, rather than elected, functionaries at each level, commanding their subordinates and using implicit threats and rewards to achieve their objectives. Viewing the company as a group which is primarily organised towards the welfare of its employees, the democracy analogy would suggest that decision-making should be through indirect elections, making group decisions by secret ballot, and electing representatives to higher levels for fixed terms (the "Shell parliament").

It is a classic theorem of political theory that people who vote in an election in some form or other must have consented to abide by the result. Employee commitment to organisational goals is crucial to organisational success (see recent concerns in the Planners Forum about corporate loyalty amongst Shell staff), and applies whether the company is public or private. Yet the employees do not elect their managers. Similarly, the notion of a loyal opposition does not receive much support in most boardrooms (although it may exist).

This analogy has linkages with soft-system methods, with the idea that organisational effectiveness can be determined only by asking all the parties involved whether the organization is fulfilling their needs. Viewing the employee as the primary stakeholder leads to this type of approach.

The **federal** model was also proposed by Handy as a suitable model for future organisations. His view is that the centre should be the centre (as in Switzerland) rather than the head as in Head Office). Only strategic planning, finance and personnel should remain central functions, and other head-office functions cut right down. Power is seen as devolved up rather than down. Shell corresponds quite closely to this model, save for

the size of head-office.

A related point is Handy's belief in the importance in such circumstances of specifying ends rather than means to subsidiaries or OpCos. He believes strongly that in future the flexibility needed will require managers to define the product rather than the process. (Handy 1990). This is somewhat contrary to developments in the IT industry over the past decade, in which the problems in accurately specifying a product have led to emphasis on quality assurance of the process. It implies that eventually we must expect a return to product quality attribute specification as the final goal.

8. Conclusions

Different analogies tell you different things, and the analogies explored here say different and sometimes contradictory things about how the Group should be viewed, and what actions should be taken to preserve it in future. The level of abstraction at which systems theorists feel safe in discussing systems in general is too high to provide prescriptive recommendations, and the feeling at the end of all this is very much the same. These analogies are good **ways of thinking** about the problem of what to do with an organisation, but they are not a **substitute** for thinking.

There are a number of lessons and ideas, especially in molecular design and evolutionary biology, suggesting how the Group should change or be managed, and how groups should be designed or functionally organised. However, the one lesson above all is that an organisation must know itself before these ideas become applicable. The diversity of people, organisations, molecules and organisms make any prescriptive statements unacceptably risky without a science of organisational design, a view of what kind of thing the company is, and better theories of adaptive response in organisations. Organisational modelling and simulation (as can be done with physical, chemical,and biological systems) may in the long term be a fruitful area of research work, but at present the underlying theory is not yet in place. A lot of the material presented here remains controversial or even "invented" during the project, and is far from being generally accepted.

We have risked some predictive or prescriptive statements at times, for example that organisational adaptation requirements in future will favour smaller, lighter organisations able to self-modify, but these are countered by other elements (such as the process advantages of large generalists in a mature market). The point at which analogies break down (as they all do at some stage) always leaves room for the mismatches to change the conclusions. Greater complexity and change is creating a need for more autonomous and adaptable organisations, but to follow this trend risks losing the essential nature of a group such as Shell. Personnel rotation is suggested as the central variable which holds the Group together. A consequence is organisational "Alzheimer's" - a feature seen in many organisations, but which is particularly bad in Shell. Computer-based systems are the inevitable reaction - machine memories to maintain knowledge when people have moved - but they themselves increase complexity, require control and may increase the non-linearity of overall system behaviour. Every benefit has its costs.

It is suspected that no-one would build a rational organisation the way a modern company is constructed, and the process of design and staffing appears, by comparison with chemistry, extraordinarily ad hoc. However, before redesigning Shell, it is crucial to look at **why** things are as they are. Learning lessons from nature is a popular approach, which is yielding interesting conclusions in a number of disciplines, and organisational design may not be an exception.

An issue which runs through organisational theory and which we have addressed several times is the nature of organisational behaviour as emergent or rational. Evolutionary and "traditionalist" approaches to management favour emergent strategy; organisational

design and strategic choice suggests a more rationalist approach. A combination is probably closer to the truth. Certain structures may favour quick action and others slow consolidation, but the action may still be right or wrong (as a consequence of retrospectively incorrect or unlucky decisions). Luck still plays a major part in things.

Another theme is the conflict between prescriptive and cultural approaches to organisational assessment. Soft-systems methods are flawed, according to most analogical approaches, since there **is** a right answer, it is just that we do not know enough to find it, and there is no reason why exploring the preferred options of participants alone would uncover it. The prescriptive view rests on the "mechanistic" nature of man. Most analogies treat man as a dependent variable, whose behaviour is predictable and who can therefore be built into equations which will eventually produce a satisfactory answer. If there are no right answers, then physical analogies have little or no role, except insofar as they bring people together in a common approach.

At the end of this review and exploration, the overall conclusion is that **there are better and worse structures and strategies, their properties should be predictable, and that bringing lessons from evolution into a science of organisational design should give us better systems and more profitable organisations, but that it is many years before we will be close to doing so, and it is far from certain that it is desirable in the first place.**

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