

Lincoln University Digital Thesis

Copyright Statement

The digital copy of this thesis is protected by the Copyright Act 1994 (New Zealand).

This thesis may be consulted by you, provided you comply with the provisions of the Act and the following conditions of use:

- you will use the copy only for the purposes of research or private study
- you will recognise the author's right to be identified as the author of the thesis and due acknowledgement will be made to the author where appropriate
- you will obtain the author's permission before publishing any material from the thesis.

Towards an ontology of transport

Transport naturalised

A thesis
submitted in partial fulfilment
of the requirements for the Degree of
Doctor of Philosophy in Transport Theory

at
Lincoln University
by
James Maxwell Upton

Lincoln University
2018

Abstract of a thesis submitted in partial fulfilment of the requirements for the Degree of Doctor of Philosophy.

Towards an ontology of transport
Transport naturalised

by

James Maxwell Upton

This thesis develops an ontology of transport that is appropriate for transportation as it occurs in all earth systems, whether physical, biological, social, or economic. I argue that the current very restrictive ontology makes it essentially impossible to understand the wider relationships between material movement and activity on one hand and economic, social, and environmental phenomena on the other. The thesis focusses on the conceptual issues.

In the broadest usage, the term 'goods transport' refers to the movement of materials from one place to another. However, its central conception is usually considered within a narrow context as a demand that is derived from other activities. Understandably then most transport research is applied to improving how systems operate and focus on optimisation and efficiency. This occurs within the context of an ambivalent approach to the governance of freight transport where what is moved within New Zealand and across borders is determined largely by market forces. This particularly economic view of the role and governance of goods transport struck me as unsatisfactory.

To address the unease that I had about this I focus on conceptual issues through interdisciplinary and explorative research that questions the normal view of transport as a techno-economic function that focus on factors that lead to greater efficiency and effectiveness in existing transport systems. The result is a conceptual framework for the unified treatment of transport in a variety of natural and human systems. The basis of the theoretical framework so devised develops ontology of transport from aspects of thermodynamics, self-organising systems, and broad evolutionary thinking. This is an approach largely ignored in previous theorising and I address these issues within an explanatory framework that situates transport within neo-materialist philosophical thinking. The framework is augmented by ideas developed from aspects of assemblage thinking and

consideration of speculative realism. In doing this I provide a new theoretical basis to address the role of modern transport that is creating problems such as climactic warming in a changing world. The ontological commitment provides a basis for theorising ways to address transport within the socio-economic problem of the more we expand transport by generating the energy it needs from fossil fuels, the more we change global economies, but the more massive the social and environmental consequences become.

The theoretical framework develops ontology of transport from aspects of thermodynamics, self-organising systems, and broad evolutionary thinking. This is an approach largely ignored in previous theorising. The model of explanation is analogical and iterative and compares goods movement in a social context with other evolutionary entities with similar structures and speculation about ontological commitments of the perceived similitude. I then explore whether the analogy is appropriate in theorising the difference between cellular, ecological and goods transport, and how the social aspects of materials transport can be explained with a new understanding of transportation ontology.

Transport has had a relationship with matter and energy since the very beginnings of living cellular systems and plays a meaningful part of the persistence of all living things, It is central to evolutionary processes and the development of complexity. Transport at different scales has the same purpose with similar abstract architecture and informational processes, that are developed to levels of complexity that rival those of modern logistics operations. Topological governance of transport systems is found to be as important as the management of network logistics systems and work together for the viability of the whole entity over time. My findings suggest that social and political discourse around transportation could benefit from a broader consideration of how entities from the scale of households to nations could benefit societal health through managing energy flows within regions and across borders

To make sense of this requires a transport ontology allowing a commitment that matter and energy interact within informational systems. I propose an ontology that is processual and allows for an order producing and active relationship between matter, transport, and energy flow to create complexity as part of the evolution of the earth. The ontology allows relationships at and between many scales entailed in 'perception-action' cycles and manifest as transport and communication. Transport theorised in this way is an analysable production function of whole entities that connects the capacity to affect with the capacity to affect with the capacity to be affected as found in all material flow processes. In summary, transport produces situations of adjacency where material get close enough for their properties and capacities to interact.

My overall contribution is the thesis that there are thermodynamic, material, and evolutionary reasons to naturalise transport and consider it meaningfully in the development of complex living systems at many scales. My project shows that when transport is theorised within neo-materialist thinking a different and richer perspective on transportation emerges that offers an alternative conceptual foundation applicable to a broad range of problems found in human systems and especially in integrated human-natural systems within developing neo-materialist thinking. My conclusions are that the earth can be seen as reliant on the transportation of matter at every level and scale and when seen in this way implies an ontological commitment that differs from the current paradigm of transport. It supports a naturalised transport epistemology and an ontological commitment that allows transport to be theorised as a universal function that is critical to every spatial transfer of matter at every level of existence.

Keywords: Assemblage theory, assemblage thinking, entropy, emergence, open systems, ontology, goods transport, thermodynamics, entropy, dissipation, informational systems, naturalised transport, Neo-materialism, Speculative realism.

Acknowledgements

Through all my study at Lincoln, Professor Chris Kissling has been a source of motivation and inspiration in helping my academic development. It began when we met as part of the regional education programme, where Lincoln University offered the Professional Masters Programme in Nelson. Chris's support and encouragement during that time helped guide me towards further doctoral study.

I am grateful to my wife Philippa for supporting and encouraging me in this endeavour that created financial and career uncertainty to our household, and the way her nerve and verve have kept us on course.

Dr Hamish Rennie has humoured me in my less than orthodox approach to tackling and completing this thesis. His broad understanding of things philosophical, geographical and background in systems thinking has guided this research, and I acknowledge him for that. I also thank Grant Tavinor for his help in grounding and shaping the philosophical aspects of this research. I acknowledge the help I received from Dr Keith Morrison for introducing me to new areas of thinking about human ecology and for helping me develop different ways of seeing the world.

I am grateful for the support of our sons, and our friends and my colleagues from previous employment, and to those I have met since being in Christchurch. I particularly acknowledge and thank Sven Hooper, Dr Lin Roberts and Dr Jean MacFarlane for their help and encouragement.

Dedicated to the memory of Rev Roy Maxwell Upton (1928-1992), my father, whose many interests live on through our sons: his grandsons. Thomas through his wide interest in the humanities and medicine. With Alastair in his love of art and architecture, and Ralph in poetry and things dramatic.

And Hamish, the grandson who inspired the poem below, through his love of music.

You are acknowledged with love.

“Grandad you have a rusty skin...”

Alas I fear ‘tis true

Wrinkled..crinkled..hair grown thin

Which time cannot renew.

My Grandson comments without guile

A child’s transparent thought

I have no answer, but a smile

And rue what age has wrought.

The outer shell is still intact

The paintwork not so bright

Though the fabric chipped and cracked

It still is water tight!

I can keep a child-like trust

Within this battered hide

Then “faith” will keep outside, the trust

And “hope” and “love” reside.

A mortal man in house of clay

That’s subject to decay

But clothed in “immortality”

When dust is blown away

21.6.92 R.M. Upton

Table of Contents

Abstract	1-2
Acknowledgements	1-5
Table of Contents	1-7
List of Figures.....	1-9
Glossary of terms.....	1-11
Chapter 1 A theory of transport.....	1-1
1.1 Freight transport as a starting point.....	1-1
1.2 An ontology for transportation	1-4
1.3 Transport as a derived demand.....	1-6
1.4 Justification of the research	1-11
1.5 An alternative ontology.....	1-13
1.6 Summary.....	1-14
1.7 Summary of chapters	1-15
Chapter 2 Review of Transport Research, Policy and Themes.....	2-17
2.1 Introduction.....	2-17
2.2 Dominant Transport Research Themes.....	2-22
2.3 Transport research and policy.....	2-26
2.4 The influence of neoliberalism on transport and borders	2-37
2.5 Research gaps in the literature	2-42
2.6 Review and summary	2-47
Chapter 3 Energy, flow, structures, and transportation	3-50
3.1 The history of thermodynamic understanding.....	3-50
3.2 Odum and energy transformation	3-52
3.3 Swenson, entropy, and structure	3-63
3.4 Energy flow and transport processes.....	3-68
3.5 Summary of implications for transport	3-69
Chapter 4 Transport and evolutionary processes	4-72
4.1 Transport processes in cell development.....	4-72
4.2 A materially active account of structuration.....	4-87
4.3 Cellular transport features found at different scales	4-89
4.4 Evolution as a material activity	4-94
4.5 Chapter summary	4-98

Chapter 5 Committing to an ontology of transport	5-102
5.1 Introduction.....	5-102
5.2 Towards an ontology	5-104
5.3 Introduction to neo materialism	5-109
5.4 Intensities	5-112
5.5 A metaphysics for material movement	5-116
5.6 An ontology of transport	5-123
5.7 Material assembling and disassembling.....	5-128
5.8 Chapter summary	5-134
Chapter 6 Application to Social aspects of transport.....	6-136
6.1 Introduction.....	6-136
6.2 Social systems and economic implications.....	6-137
6.3 Common features in social systems	6-141
6.4 Social ontology	6-144
6.5 Eukaryotic self-governance	6-152
6.6 Intensive processes that change social activity.....	6-156
6.7 Chapter summary	6-159
Chapter 7 Methodology, Examples with explanations.....	7-161
7.1 Introduction.....	7-161
7.2 Methodology consistent with my transport ontology	7-162
7.3 Canterbury plains and intensive change	7-167
7.4 Hydrocarbon powered rail transport	7-174
7.5 Kaikoura Coast and transport systems.....	7-179
7.6 Social change, scarcity, and waste flows.....	7-181
7.7 Chapter summary	7-184
Chapter 8 Conclusions.....	8-186
8.1 Introduction.....	8-186
8.2 Returning to the research question	8-189
8.3 A broader definition of transport.....	8-192
8.4 Contribution of ontology.....	8-194
8.5 Future applications.....	8-196
8.6 Final Summary	8-197
References.....	8-199

List of Figures

Figure 1 The circular flow between firms and households.....	1-6
Figure 2 Supply, demand, and equilibrium.....	1-7
Figure 3 Relation between GDP and freight movement	2-19
Figure 4 Freight movement by mode	2-26
Figure 5 Draft transport policy research themes.....	2-30
Figure 6 Energy flow and natural structure	3-54
Figure 7 Odum: System of generic symbols.....	3-55
Figure 8 Autocatalytic production	3-56
Figure 9 Feed forward and feedbacks	3-57
Figure 10 Odum time and territory world scale	3-58
Figure 11 Feedback mechanism.....	3-59
Figure 12 Change in entropy production.....	3-64
Figure 13 Bernard cells	3-66
Figure 14 Organised custard	3-66
Figure 15 Hexagonal patterns in Gore Bay NZ and Halls Gap Aust.	3-67
Figure 16 Autocatakinetic process.....	3-68
Figure 17 Concept of first cell	4-73
Figure 18 Chemiosmotic properties of cells	4-74
Figure 19 Warehouse loading dock	4-79
Figure 20 Physical transport in cells	4-80
Figure 21 Cell transport - Macroecular.....	4-80
Figure 22 Ecosystem transport.....	4-81
Figure 23 Cell transport - Molecular	4-82
Figure 24 Mine transport.....	4-82
Figure 25 Bacteria with vision.....	4-83
Figure 26 Two way transport.....	4-83
Figure 27 Mine transport 2	4-84
Figure 28 Like ants on a twig	4-84
Figure 29 Visionary concepts	4-85
Figure 30 Analogy of the scale of the physical	4-87

Figure 31 The Roman ‘cell city’ of London.....	4-89
Figure 32 the ERT network of <i>M. tuberculosis</i>	4-91
Figure 33 Map of shipping network.....	4-92
Figure 34 Cycle of information and operational testing.....	5-119
Figure 35 Ontology of thermodynamic system	5-120
Figure 36 The ‘city cell’ of Dubrovnik	6-145
Figure 37 Footprint vs sustainable levels.....	6-154
Figure 38 Changes to land use in Canterbury NZ. (2000-2016).....	6-158

Glossary of terms

Capacity	Used in the interactive context where one thing has the capability to affect another, is always considered in terms of the other things capacity to be affected. Capacities are always real but may never actually take place. Capacities are real in a virtual sense. More than just possible, as this suggest a reliance on forms. Capacities depend on properties. Capacities to affect must be thought of in relation to the capacity to be affected.
Emergence	Something not found in causes, and that exists only through the interaction of the causes.
Emergent Property	A resulting new or novel property of a thing. Finite and countable.
Entities	Possessors of a set of properties. Material things generally.
Flat ontology	All entities have the same ontological basis. For example, a business lobby group has the same ontological status as an individual business person.
Gradients	A difference in potential that generates transport of matter as flow. Generate the moving parts of larger wholes.
Materialism	Scientific explanation of activity in the world that happens without its meaning requiring the notion of value, purpose or meaning.
Metallurgical	An alloy of the endeavours of many bodies, that is worked on by geological, biological, and human agencies.
Multiplicity	Specifies the structure of spaces of possibilities. A neo-materialist alternative explanation of 'essence'.
Morphogenesis	The production of stable structures out of material flows.
Neo-Materialism	The metaphysics of new materialist thinking.
Nomological	Something that is a proposition of a law, or principles that resemble laws. Applies to laws of nature that are not logically necessary or able to be explained starting from a theory.
Ontology	A set of entities assumed or said to exist in the world. It includes a commitment to types of entities asserted to exist. We can consider

	ontology as the way to specify what can be conceptualised as being real in the world.
Possibility Space	A set of points in abstract space with a higher probability of becoming actual than the other points. For maximum disorder to be directional there must be a point – an attractor - that the population is attracted.
Properties	Always actual and a physical state, such as the sharpness of a knife.
Resilience	Capacity to withstand ongoing pressures or recover from disturbance.
Singularities	A point of minimum tension. Highly invariant properties as the existence and distribution of points or sets of points. The possibilities with the highest probability of occurring are topological singularities acting as attractors. (DeLanda, 2011).
Simulation	Understood as reproduction, replication, and recreation.
State space	The space of all possible states for a process represented by the set of all points in a concrete space of possibilities within a definite structure.
Tendencies	Autonomous entities are characterised by their actual properties as well as by their tendencies and capacities. Tendencies and capacities can be potential or virtual. For tendencies it is the distribution of singularities that sustain their reality when not actually manifested.
Virtual	A form of reality. For example, a capacity need not be actual to be real.
Whole	A whole is an entity with its own properties.

Chapter 1

A theory of transport

In the broadest usage, the term transportation means the movement of material from one place to another. From my exploration of the many instances of transport activity found in the world it seems incomplete to consider transportation of goods mainly as a derived demand of other production and consumption activities. That is, to label transport as a mere consequence of some other economic or business activity falls short of being a complete explanation. Confining transport to that of being a derived demand following on from other activities seems to have limited the investigation of transport systems to areas of applied research with a focus on optimisation and efficiency measures. This particularly economic view of the role of transport struck me as unsatisfactorily narrow and anthropocentric.

1.1 Freight transport as a starting point

The word transport is derived from the Latin *transportare*, being an important route - a transport artery. To transport something as a purposeful action extends its general meaning to encompass activities in which material is intentionally moved across a border or through a port or gate to a different physical place in the world. In addition, the activity of transportation is also described in processes other than commercial goods movement. Blood flow through the body is one such transportation process where materials are moved, as are river systems and deltas and weather systems. At a cellular level 'cell transporters' move ions and molecules across cell membranes, and this recently observable process seems to be surprisingly like the role that city walls and gateways play in regulating activity into and out of a city. Transport naturally occurs in river systems that result in the movement and shaping of stones, as found in coastal currents responsible for the littoral drift along the Canterbury coast line. Examples found in ecosystems include the dispersion of seeds by birds and the migration of fish between breeding and feeding grounds. These natural transport systems use potential energy differences that occur in the environment to move mass through distance, in accordance with thermodynamic principles of energy flow. The extent to which transport system activity is found in all living processes opens the field to wider questions about the place that transport plays in the creation and persistence of life in general. The questions this raises led me to consider the proposition that the way freight transport is theorised in the literature may have lost in its explanation an appreciation of the wider natural principles at play and focus too narrowly on economic values in the understanding of what constitutes a transport system. It may be

that goods transport has never been fully explored in terms of energy flow, and that transport, energy and matter generally are not considered interdependent because the current presuppositions of goods movement exclude the need for a different interpretation.

What I am proposing is placing ontology of transport systems at the centre of this enquiry. There is an opportunity to explore the kinds of entities that would have to exist according to a fuller account of transport processes found in the world. I have observed that transport gets a mention in many disciplines but only in a way that is of secondary importance and not in a way that is significant in terms of the motivation and outcome of that research. In medical research for example, the way chemicals are transported supports the main health enhancing objectives of the research. There seems to be very little focus on a general transport theory as a specific research activity. This is understandable as it reflects the primary concern with research designed to find practical outcomes for health issues, bridge strength, accessible cities, and other movement issues. In this thesis, I probe more deeply into the theoretical assumptions about transport that are accepted as given in this type of research. The last book directly considering transport theory is titled *The Theory of Transportation* and was published by the American sociologist Charles Cooley in 1878. The way that he described transport phenomena at that time is surprisingly consistent with how we still talk about transport now. Given the advances in technology the suggestion that the framework he offered one hundred and fifty years ago could still be considered sufficient in addressing the current understanding of social and economic progress and development overlooks the vast developments of scientific knowledge over that time. The theoretical side of transport processes has been left behind and current research is almost completely dominated by applied research focussed on improving efficiency of transport as a cost of production and distribution.

What has changed since Cooley wrote about transport is that the social and material aspects of transport have reduced in importance with the present characterisation of transport being primarily an economic idealisation: an abstract model relating distance, time, and cost. The visceral reality of 'getting places' is far different to the physical world that an early long-distance transport pioneer Fredrick Dennison faced when he drove the first New Zealand made vehicle between Christchurch and Oamaru -a five-day task in 1900- complete with river crossings and mechanical failures. Dennison's dalliance with oil fuels, including a subsequent explosion and fire which destroyed his luggage, was part of the pioneering exploration of the potential that oil energy offered transport systems. Since then increasing reliability of roads, engines and communications have progressively reduced our perception of distance and expanded a sense of our command over time and space. While technology and oil has advanced our ability to transport ourselves and our goods, our

fundamental understanding of transport as a thing remains impoverished and fails to account for the phenomena in a fully illuminating way.

Cooley describes the significance of technical and mechanical progress in extending the reach of transportation (Cooley, 1894). He describes how transport progressed from manpower to beasts of burden to a combination of a beast plus a sliding and then wheeled dray. Following this came the harnessing of chemical forces found stored in coal “through the mediation of steam, electricity etc.” I wondered at first why there was no mention of combustion engines in what is otherwise a fair account of modern transport, but of course he was writing fifteen years before Dennison made his five-day journey from Christchurch to Timaru. His use of ‘etc.’ just so covers the future development of transport progress through the immanent discovery of the potential stored in rock oil, and the quantum leap in transportation capability about to create power centres and complexity through the introduction of engines *that you feed* had in household, city, and global entities. The societal changes since Cooley considered what made up a transport theory are immense.

The static nature of transport theory led me to focus on what a revised theory would mean for the way that goods transport is understood in human social systems. Specifically, I wondered whether a new ontology for transport might provide a better understanding of the social effects of materials movement through examining the thermodynamic, evolutionary, and socio-economic reasons for transportation. I now address this question via a focus on freight transport with its spectacular increase in distance and tonnage made possible by fossil fuel powered, thermodynamic engines that have radically altered freight transport, and our world. I could equally have chosen public transport or private vehicle use for this journey but chose to narrow my focus to goods or freight transport to allow deeper enquiry into the relationship between transport and energy and emergence. My approach is in contrast with more economically driven research of freight movement as something that is a derived demand borne out of the classic economic frictionless model of production and consumption (Gorringe, 2001). This previous earlier framework suggests a theory that remains tacitly linked to the classical roots of molecules as marbles and the science of behaviour of gas in a bottle and the consequential economic aspirational goal of describing systems that naturally seek out a state of equilibrium.

In a broad sense I want to know how the concept of transport should or can be explained within an ontology that addresses evolutionary mechanics and explores what appears to be an apparent end-directedness of even primitive and natural forms of transportation, in a scientifically coherent way. I want to explore how transport fits with such a view of the world, and to understand why transport happens in the environment and in society. I am going to argue that transport is ubiquitous within

the biosphere, and that surprisingly, the wider questions about what it is and how it serves systems at every level have not been addressed. I will do this through an exploration of transport in a thermodynamic and an evolutionary world, of which the American mathematician and biologist Alfred Lotka (Lotka, 1922, p. 147) observed that “in the struggle for existence, the advantage must go to those organisms whose energy capturing devices are most efficient in directing available energy into channels favourable to the preservation of the species”. The directed and contained flows that Lotka describes are enabled by the transport of energy and matter from place to place. These active and energetic processes, where everything flows, and nothing stands still, transcends in both scale and grandeur the common description of the act of transport as ‘a derived demand’.

1.2 An ontology for transportation

There is a growing interest in ontology and ontological reflection as a way of making explicit the assumptions upon which all knowledge depends (Fulbrook, 2009, p. 18; Hirsch & DesRoches, 2009). All physical theories assume the existence of things that are real, and that collection of things form the commitments of an ontology. At a human scale, things that are thought to be real in the world are accessed through our senses directly or are conjectured to exist based on what we can observe with our senses. With the development of more precise mechanical and scientific apparatus new ways of accessing the things in the world are made possible and this new observation and experience can challenge previously made theoretical conjectures based only on human level contact. As information obtained from beyond our naïve senses expands, new questions are raised. An example of this in evolutionary biology is ‘the vital question’ of how life developed, a question the answer to which was previously empirically inaccessible (Lane, 2015b) and through my research is found to have an interesting transport component.

Ontological change has frequently been factored into periods of scientific progress. For example, the historian of science John Gribbin recounts how the enlightenment scientist Benjamin Thomson’s (Lord Rumford’s) work on heat, contributed to the downfall of the caloric model (Gribbin, 2002). Caloric was understood in the eighteenth century to be a fluid associated with heat. The problem that Thompson saw for the caloric model was it arose from the observations he made during his work with artillery. Thompson was a practical inventor and engineer who thought there could be other ways of understanding the phenomena of heat that leaked out of materials. He observed that when a cannon was fired without a cannon ball the barrel heated up more than when fired with a cannon ball. Caloric was thought to be a fluid released from the metal, but based on that, the barrel should heat to the same degree when the same amount of gunpowder was used. At first, he thought it to be a competing model of heat and being a vibration might explain this. He then found

that when cannon boring occurred, heat was continuously produced so he questioned how this could be if caloric was a finite fluid in the metal. The eventual rejection of the caloric model and its implied ontology of *heat as a substance in favour of heat as a state*, opened the way for further discoveries and progress in physics and chemistry. Thomson's work began a move to associate heat with motion and establish a new way of thinking that helped develop the idea that there is motion of individual atoms and molecules in material things.

The formation of any scientific view of the world has an implicit ontology of what the scientist is committed to accept there is in the world that supports that view. Scientific and observational advances can therefore create a case to review ontology, especially when new information about properties and capacities, particularly coming from investigations of the micro world, are revealed. The understanding of the nature of heat brought about by the scientific observations in the boring of cannon barrels is just one example of an ontological shift. There may also be a case with new discoveries about the nature of transportation.

This kind of ontological change provides a suggestive model for my method here. Transport may not be adequately categorised in economic terms as being a derived demand of a production process. Transport functions can now be seen and described in basic cellular activity, suggesting it is a part of a highly developed set of interactions found in all living systems.

My aim is to find scientific explanations about transportation in living systems and develop an explicit transport ontology appropriate to an understanding of transport as a thermodynamic, evolutionary, and social phenomenon found throughout the living world. If it started with the beginnings of life, an ontology defining transportation as a part of the chemistry and biology of all things living may open the way for further progress in understanding transport within the context of living, evolving, and dying systems and perhaps even its role within groupings and societies of living things. This may even influence our understanding and formulation of social policy regarding transport.

The value of a new ontology is that it may provide the opportunity to ask new qualitative questions (Denzin & Lincoln, 2000, p. 18) and for this thesis, about goods transport. Firstly, for the "trans" (from the Latin for 'across') in transport to occur energy is degraded in a manner consistent with the laws of thermodynamics that requires that something is gained, something is lost, and something is conserved. The "port" of transport refers to the potential to facilitate matter and energy flow through and between systems. The world that goods of freight transfers through is a material, spatial and temporal world where energy potential is lost every time something moves. Energy

movement in living systems, if it is to be subject to the laws of thermodynamics and operating in open systems is not merely guided by the “invisible hand” of classical economics. I will explore the idea that living systems take energy from outside of themselves, from the environment and use it within to produce a more organised state. Focussing on thermodynamic movement, the transport processes and the borders that define what is “inside” and “outside” a given entity offers new ways to understand transport. In working towards an ontology for transport, certain beliefs, ideologies, and processes need to be questioned, rearranged, reviewed, and reordered.

1.3 Transport as a derived demand

The circular flow economic model is shown in Figure 1 and so describes the basis of economic activity where the primary relationship in creating output is between firms and households. Labour and capital operate in a reinforcing loop where supply and demand are rewarded by the clockwise flow of money. All other influences are theorised as secondary to or as un-encompassed ‘externalities’ to this process. Daly says that the ‘steady state’ neoclassical model takes tastes and technology as given, and its mode of evolution is by adapting and

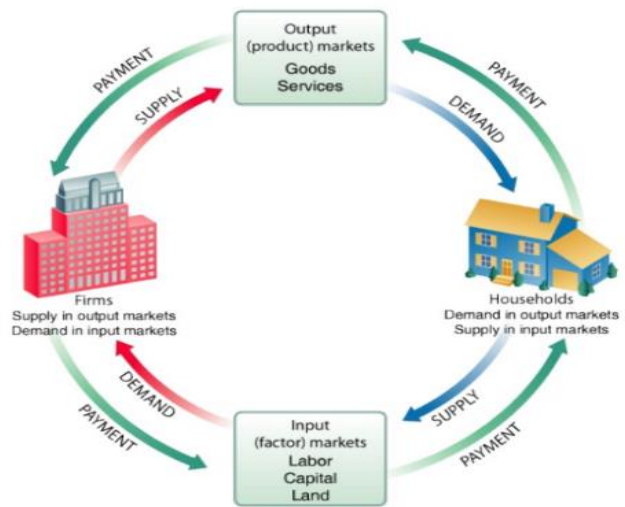


FIGURE 1 THE CIRCULAR FLOW BETWEEN FIRMS AND HOUSEHOLDS

SOURCE: (VILLANUEVA, 2013)

by growth in biophysical dimensions (Daly, 2008). The model, of which I show a fuller and annotated version in Figure 2 considers that the wants of the consumer are unlimited and is not concerned with concepts of finite resources as technology is innovative enough in its application to maintain growth and consumption. Should the depletion of a resource loom on the horizon, the response of the standard economic model is to raise the price of that resource to force greater efficiency of production. Greater efficiency is thus mandated by man as innovator and re-creator of a world where these qualities are applied to satisfying individual preferences that lie at the route of all value

(2008). In this non-physical conception of the world the activity of transport is theorised as one of the consequential effects of limitless economic activity, and so derives its demand from the needs that the model dictates. It is a model of flows where there is no specific mention of energy flows either in or out of the system. While not stated in figures 1 or 2 transport services are part of the counter clock wise demand/supply process, as an abstract cost of production.

The dominant conceptualisation over recent decades of transport in economic terms has been partly enabled by political events such as GATT/WTO rounds that stimulated goods movement through reduced tariff and quota regulations. Between 1950 and 2005 world merchandise grew at a rate three times faster than GDP (*World Trade Report*, 2007, p. 243). At the same time physical trade barriers have been lessened through declining transport costs and technological improvements in transport and logistics (Feige, 2007).

Freight transport also continues to increase and has continues to do so at a faster rate than GDP. Predictions about the coupling of transport and economic growth are that the relative increase in freight transport will continue to be greater than economic growth, and will do so with a co related proportional increase in emissions and the rate of fuel use (Baas, 2007). Conversely, globalisation of trade is predicated upon freight movement being a small cost of the overall transaction with an expectation that costs will continue to reduce through technological aid and innovative change.

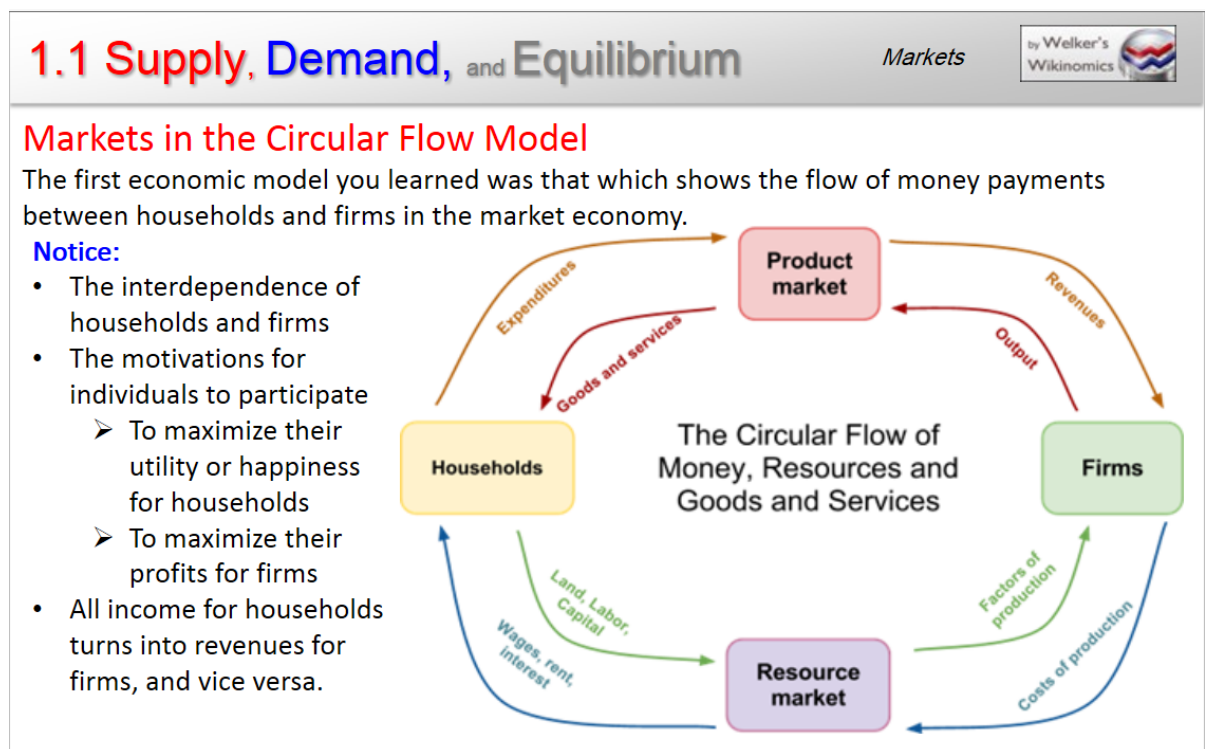


FIGURE 2 SUPPLY, DEMAND, AND EQUILIBRIUM

SOURCE: (JACKSON, 2015)

(Easton, 2009; Rubin, 2008). An example of a complex logistics tool that has helped to this is just-in-time (JIT) production planning where time sensitivity for materials or parts activates the supply of inputs needed for the output required. It is a transport driven tool in two respects having been first developed for Japanese car manufacture, and for its heavy reliance on fast and reliable goods transport. JIT systems support Hesse and Rodrigues's argument that complex transport systems function as more than a derived demand of production, by enabling strategies of minimum capital tied up in inventories, and by the use of transport as mobile warehousing (M. Hesse & J. Rodrigue, 2004). Linking suppliers contracted to provide rapid delivery for production creates an agglomeration effect that meets economic goals of short lead times changing market demand. JIT therefore influences the structure of commodity chains because a business can use low freight transport costs to strategic advantage. Emmet (2005) describes freight transport as being an essential function in product supply chains and while this seems limiting, it also opens the possibility that a theoretical description of the transport process is not just about the mode, but also about the context of what it does. In this context Lambert (2004) focuses more on freight transport as an operation providing for the movement of materials and goods from point of origin to point of consumption, as a key logistic activity. Here transport is described as performing as a modernised version of Cooley's (1894) movement of things from one place to another. Developments such as JIT suggest that activities of transport are an evolving activity in systems where there are more energy flows and better communication that change relationships between producers and markets and the social structures that transport serves.

The etymology of transport includes 'trans' 'to cross' and at a time of relaxed borders supports greater flows of all types of materials from one social system to another. There has been a change over the last 50 years in the importance of borders in relation to nation building. New Zealand economist Brian Easton argues that the change in political agenda in the early 1980's lead to the dramatic collapse of New Zealand's nation building vision (Easton, 2001). The effect of that policy change continues in the form of a lack of contemporary appeal for industrialisation strategies and reinforces a liberal approach to economic matters where the autonomy of the firm is prioritised over the national economic interest (C. Baker, 2009). The move away from a focus on nation building is manifest in the abolishment of foreign investment controls, relaxed border protection, the exposure of New Zealand business to imported goods, and the selling of state owned businesses to foreign companies, all of which have transportation implications. Easton argues that the 1984 government ventured unknowingly down an economic policy strategy without fully realising at the time that it would undermine nationhood. The changes instigated in 1984 included using the market to regulate resource decisions and so reduced government controls, so giving controls generally the

negative connotation as being interventionist, and that applied “especially with regard to border protection” (Easton, 1997, p. 13).

The ‘port’ in transport presupposes a place that controls entry and exit; a mechanism of directionality with selectivity capacity to control that which crosses a border. The economic functions of transport across borders brings new ecological pressures. Biosecurity systems have increased as regulations relaxing the flow of freight over borders decrease. The Ministry for Primary Industry has 600 staff and 30 dogs working New Zealand’s sea and air ports and mail centres with the aim of stopping pests at the border (Baird, 2012). The concern that Baird, who is a biosecurity professional and commentator has about this is that the world is run by bugs and that the natural world is a 3.8-billion-year research and development laboratory ‘with most of the answers to our problems.’ He says that while we live on a biological planet, it is a world run by politicians, economists, the stock market, and multinationals with the natural distribution of animals, plants and people accelerated using wheels, air, and sea transport. In this context the risk transport poses can be described as bringing new entities into contact with new places with largely unknown consequences.

Defining transport as a simple cause and effect physical processes (vis-a-vis a derived demand) is a limited description when considering instances where materials are moved against entropic or downward natural flow, for some end. A salmon swimming up rapids is an example of this, as is the movement of a proton across a cell membrane against a physical barrier which requires energy expended for a specific end. This leads to the question of whether the apparent control over transport may be less about economic factors of ingenuity and innovative thinking, and more a manifestation of core processes central to evolutionary and living systems.

In my investigations the reasons as to why freight moves at all turned out to require a far deeper questioning of how living systems generally can be understood, beginning with questioning what transport has to do with why life is the way it is. The more general question is also being addressed by evolutionary thermodynamic biologists, for example where Nick Lane (2015), an evolutionary biologist and a leader in this field says there is a black hole in biology regarding how life in general came into being. His concern is that current research is not addressing the reasons why cells work the way they do and so his project has similarities to my questions about why transport works the way it does. Advances in molecular biology can now show renditions of how cells function, and what scientists are finding in cells includes an extensive description of the transport activity. If that is the case and for the health of society, our understanding of transportation theory needs to be deeper and broader than is currently accepted.

Given transports ubiquitous presence in all sorts of systems it seems that access to transportation paths and the expansion of transport modes and mechanisms is taken for granted as a factor in social and economic progress. The characterisation used to consider transport, and the viewpoint chosen determines what transport entails in that instance. There seems a tremendous amount at stake with how we conceptualise transport, as the mechanism strongly affects the kind of world that develops. Taking a myopically economic view of the phenomenon may miss all the rich connections that the concept of transport has to other important domains. For example, a recent connection, of ontological significance in my argument and developed in later chapters is the identification and an expanded understanding of transport along the lines that transport and communication are parts of the one process (Tiffin & Kissling, 2007).

The potential to transport materials over long distances and over borders strongly influences the kind and type of work and advancement of opportunities available at a social and community level. For example, economic decisions about production facilities mean that factories can be replaced by the international supply chains enabled by low cost transport. Fisher and Paykel exercised this capacity when they shut down their Mosgiel plant with the loss of 430 jobs and moved production to China (Hartely, 2016). The shift of the production facility away from the Dunedin workforce was enabled by gateway controls that allow the same type of white ware products also to cross borders and enter New Zealand. The potential for globalised production to change the social structure of a region at this scale raises questions about the theoretical basis that allows transportation enabled social change. Where transportation is a factor in the production of goods its importance is subsumed by the pragmatic preconditions suited to that field of endeavour – that specific window of interest. This narrowness of this appreciation of transportation potential precludes a satisfactorily inclusive explanation specific to goods transport and for transport ‘within the world’ in the general sense.

At an academic level transport function is accepted as something that occurs and is beneficial in all sorts of research without it necessarily being the central theme of study within those disciplines. Its physical functionality in time and space is taken for granted and its theoretical basis remains under-researched. Science is interested in mechanisms of transport and the modifications that can be made to cellular and ecological transport in a similar way to how it is treated in social systems. There is a need to commit via an ontology to what transport is and so develop a deeper understanding of the nature of transport and its relation to thermodynamic and evolutionary processes.

1.4 Justification of the research

The rate of social and technological change, particularly since the industrial revolution, is characterised by changes in the rate of materials movement and the speed of communication. For example, a refrigerated shipment of meat to the United Kingdom in 1882 shows the early centrality and dependence on goods' transport of New Zealand's past prosperity and, because physical distance remains a constant, a technological gateway to our future. Transport over vast distances is exposed to the risk of possible supply chain disruption should there be future limitations of energy supply, and this makes the topic contemporary, challenging and important. Energy usage by transport is also central in predicting and modelling future scenarios of public wellbeing and trends in economic growth. This makes the topic pertinent and timely and indeed deserves to be included in policy discourse about the movement of materials and the borders that are crossed.

If we accept that the earth's store of hydrocarbon energy supplies is finite, then how we manage our socio-economic future is not a constant in the equation of the quantity and quality of life (Smil, 2003). The supply of hydrocarbon fuel generally exceeded the demand for its use over the past century and this enabled a pricing strategy that enabled an entirely new range of goods to be transported. The significance of the capacity to do this continues to impact on how households, villages, cities, and countries manage their social and economic relations. Cheap energy enabled transport volumes and distance travelled to expand without the need to answer questions about the long-term viability of the systems supported by the embedded energy value within the goods moved, or the social impact of moving the locus of production of these good. The expansion of transport systems has sped up the rate of use of high quality energy fuels and consequential flows of waste heat into the environment. One of the arguments of this thesis is that in the face of this transport bonanza, the political significance given to transport social issues focuses narrowly on questions of marginal efficiency, accessibility, and safety management. This suggests that transportation longevity remains outside core economic theorising. If we accept that 'materials' are transported, then we say something about how the world is viewed generally if we relegate materials to the status of factors of production. As transport is entwined in socio-economic activity, my probing of the identity of goods' transport systems questions, quid pro quo, the ontological basis of the material world it moves and shapes and in so doing how it shapes and is shaped by the social environment. By implication, my analysis of transportation systems provides a platform to theorise more generally about material relationships and complexity found in the natural environment and in social and economic systems.

The economic imperative for transport expansion and reduced barriers to trade means that commercial research solutions are directed to solving problems of applied efficiency and cost issues. There is virtually no current theoretical enquiry about the role of transport in the social-material world entanglement that adequately explain the significance of transport interactions that affect social and cultural materials. The result is that research programmes that include goods' transport systems do not have a clearly grounded starting place from which to consider the future of freight movement outside of the current ideological framework. This issue is addressed by Markus Hesse, an economic geographer who in thinking about it proposes more detailed investigations be carried out within the existing framework (M. Hesse & J. Rodrigue, 2004). However, this merely entrenches and embellishes the current methodology and fails to deeply challenge the presupposition that it is a service role that transport plays in the modern economy. There is room to open out the discussion, and approach transport activity as far more significant in the persistence of life on earth. Such a direct look, and new theorising about metaphysical explanations of the nature of transport in complex functions does not currently exist. What we do know is that transport systems can react quickly and efficiently to a range of changes to social and economic activity that are driven by political, social, and globalised issues. This makes the capacity of transport a powerful tool of change and control. However, the question of a materially finite world persists where no political-economic ideology can change the finite quantity of low entropy stores of hydrocarbon energy.

This dangerously paradoxical situation draws into question why there is such a lack of credence given to predictions of hydrocarbon scarcity while the option to keep expanding transport continues. This is not only the case for goods transport as the magnitude of the demand for energy for all forms of life is rarely considered explicitly (Lane, 2015 p90). Dryzek is dismayed at the lack of influence there is on transport decision making in the political-environmental discourse where he says that the basic entities in the current argument are 'brute matter', 'markets, prices and energy substitution' (Dryzek, 1997, p. 63). During the twenty years since he wrote this the number of tonne kms of goods moved continues to increase (Transport, 2015) while energy consumption for the sector plateaued in 2004 and began rising again in 2015 (EEA, 2017).

Within New Zealand transport research tends to centre on passenger transport and urban congestion, as reflected in funded research (NZ Government, 2008) and freight transport has received relatively less attention and has been somewhat of a poor cousin to other transport modes (2008). The prevailing discourse about freight transport seems under theorised and inadequate in explaining how freight transport systems benefit or harm the ongoing health of society. If the

purpose of science is to benefit society, then fully understanding the role of transport should inform the debate about how freight transport affects the society it serves.

Improving the theoretical basis of transportation should also lead to better informed practical advice for policy makers to act upon. Specific and practical questions to address here include a better understanding of the endogenous and exogenous drivers of freight demand, research about the importance to the New Zealand economy of freight systems that are inherently effective and not just efficient, and the development of a language useful for future policymaking. Any one of these could be an important outcome of a new ontology of transport systems.

1.5 An alternative ontology

What would an ontology be like that explains and situates goods transport within living systems and informs the development of healthy and sustainable social systems? To start answering this question I turned to the relatively recently developed field of ecology, and specifically to the work of Howard T Odum, an American ecologist known for his work relating ecosystem dynamics with the energy that flows through them. HT Odum, one of the first systems' ecologists, drew from his research a similarity between the need for continuous fresh energy flows to sustain both natural systems with energy flows through human society. Of interest to me and my research is that Howard Odum visited the University of Canterbury as an Erskine Fellow in 1979. During his stay at the Joint Centre of Environmental Sciences he co-authored *Energy and the Environment in New Zealand* (E. C. Odum, Scott, & Odum, 1979) It is a secondary school text book that incorporates his systems thinking approach to flows, interactions and cycles in the sustainability of all sorts of systems and on many scales. The publication also acknowledges the help of Dr John Hayward, who is recognised for his pioneering work in resource management, and a former Director of the Lincoln based Centre for Resource Management, who is credited as having helped with the publication of the 'modern biology course' text (E. C. Odum et al., 1979). In his work he describes flows and movements that are found in the world and offers a macro scaled overview of the world in its entirety which he describes as being a thermodynamic energetic heat machine (Howard Thomas Odum, 2007). He sees the world as a unified thermodynamic system, and describes energy flows as eloquently as Herbert Spencer described the nineteenth century pre-Darwinian understanding of evolution as "an integration of matter and concomitant dissipation of motion". (Spencer, 1862, p. 215). His quantitative and qualitative work further develops upon Spencer's early and pre Darwin description of evolution as "the transformation of the homogenous into the heterogeneous, the indefinite into the definite, it is also a transformation of the incoherent into the coherent". (Spencer, 1862, p. 215).

In the natural world energy appears to flow through ecosystems such as forests and lakes, and around the globe as wind and sea currents, and in its originating form as heat from the sun. Odum describes how the sun and the turning earth create giant heat engines that interact with photosynthetic and respiratory processes by causing the winds and currents that transport raw materials to places of production (Howard Thomas Odum, 2007). In this thesis, I draw on such analogies to develop arguments that consider freight movement as a related type of global energy movement that creates concentrations and dissipations of power and complexity as a novel idea not usually found in the explanation of social development. Developing a transport ontology within this framework provides a deeper understanding of the purpose and process of energy/goods movement. It offers the opportunity to learn about which thermodynamic arrangements and flows are ultimately durable, given the near two-billion-year head start that ecological systems have on human economic activity. This of course requires social systems to be considered as part of living systems, which again requires an ontology different to that which is presupposed by our current socio-economic system to consist of brute matter and based on a heritage of human exceptionalism.

The methodology I settled on for this thesis included an iterative process, where observation, explanation and questioning and application to case studies and scientific discoveries of transport mechanism were often revisited and reconsidered in an effort 'to think things out, see big patterns and understand them'¹. This approach suggested to me that there is accessibility to the real world and that knowledge can be acquired through direct observation and experience. This in turn led me to consider seriously materialist and realist explanations and the exploration of the ways that 'brute matter' and social structure are part of a 'transformation of the incoherent into the coherent'.

1.6 Summary

This thesis argues that an understanding of why and how transport happens in any situation is totally integrated in a co-dependent understanding of materials, their properties, and their history of development. This at first appears to be a more general issue of how we account for complex material interactions and structures in the world and is justified by the extensive patterns of transport found within those structures. There are ontological commitments required because transport systems are found in human and pre-human development, with a significant factor being that natural systems developed without the presence of human minds but resulted in similar

¹ Paula, when describing that her father functions on an abstract level, in a novel by Donna Leon (2009, p. 168)

structures. This question of dual development (or not) is, or should be, at the centre of transport theory. The possibilities of this led me to think that an understanding of how to manage and develop social transport systems firstly needed to address the actuality of what a transport system is. At the deepest level the question is: do human-structured transport systems have a different ontological basis to transport systems that originated millions of years before human habitation? Most research on goods transport systems don't ask this question and focus on current developments in logistics and technical efficiency without any reference to other forms of transport found in natural systems. If there is a general theoretical basis for transport, how do we account for transport designed and managed by human minds? A better explanation of transport systems' theory cannot be made unless the explanation is embedded in a cogent explanation of materials and their properties and the way humans are embedded in those material systems. The aim of this thesis is to generate and explore a more correctly posed problem about how transport developed, develops, and operates in the development of complexity.

1.7 Summary of chapters

In the first part of this thesis, through reviewing thermodynamic and evolutionary systems I provide evidence of a lack of ontological clarity about what we can observe about transport systems and consider what those findings mean. In so doing, I start from an assumption that transport theory is currently incomplete, and that a new and richer account of transport systems can benefit through a commitment to a soundly based ontology for transport. To explain this at a metaphysical level, and towards an ontology, I compare the results with other philosophical positions that offer explanatory and processual epistemological ontological foundations.

The flow of the argument is guided by the very general question of *why freight transport happens at all*. To find a richer account for transport I broaden the field of interest to include research disciplines (e.g., systems ecology and thermodynamics) that might possibly provide an understanding of the causes, forces and structures that come together in systems that move goods from one place to another.

In Chapter Two I review literature on current goods transport research and thinking and identify examples of the current presuppositions of the role of transport. This provides an understanding of the current economic orientation of the ontology of freight transport and its adequacy in addressing key issues.

Chapter Three considers transport as movement with a reliance of motive power from an energy gradient. The aim of the chapter is to establish clarity about the mechanics and outcomes of

thermodynamic transportation and energy movement with a focus on directionality. To illustrate a particularly rich understanding of energy flows I rely on Odum's work with ecosystems to describe macro and generic thermodynamic flows found in the world. By defining the nature of transport in thermodynamics systems I can expand the definition of transport to that of an active part of the development of complexity in systems. This situates transportation within bio-chemical and mechanical processes that develop complexity and are regarded as living systems. The resultant transportation activities are then seen as intrinsic to processes where the outcome is the organisation of matter.

Chapter Four questions the relationship between transport and the evolutionary development of living things. What that might tell us about transport's role in the development of the world is considered along extending the involvement of transport to a description of evolutionary processes. In contrast to evolution explained primarily as natural selection I explore an evolutionary origin described in terms of thermodynamic flows through physical cell development, and how transport is involved in the directionality of that flow.

The chapter proposes that transport is a vector integral to thermodynamic evolution by describing the functional contribution that transport makes to maintaining identities like cells and cities, and so describe a teleology for transportation systems.

Chapter Five addresses ontological commitment for an expanded understanding of transport. An ontology is drawn out that situates transportation within a thermodynamic and processual evolving world. This requires that flows that try to minimise the potential across systems are selective towards complexity and that complex transportation structures develop to facilitate this.

In Chapter 6: I consider how the world is seen at a social level, where there is a challenge to the presuppositions of neoliberalism, starting with the concepts of individual choice, invisible hands, and hegemony of market forces. The management of transport in social systems takes on a far wider role than that of being a derived demand of production.

In Chapter Seven I consider through examples and analysis how my transport ontology could influence the way transport is considered in the defining and maintaining social structure, and planning for social development.

Chapter 8 is the conclusion chapter where I revisit the research question and draw together the main threads of my argument and point to areas of future application and investigation.

Chapter 2

Review of Transport Research, Policy and Themes

2.1 Introduction

In this chapter I review the types of research that informs transport decisions at a policy level as well as for transport operations and the provision of infrastructure. The review includes economic research designed to stimulate growth in Gross Domestic Production as well as the way that transport needs are forecast. I review the economic, political, and social interests of transport, and the treatment of efficiency, logistics and social goods such as safety and accessibility. From my literature review I identify the presuppositions that underlie the way goods transport is thought about and surmise the ontological assumptions that support current suppositions made about goods transport and transport systems more generally.

For most people goods transport is an activity largely taken for granted and assumed as activity created by business, and economic development. (M. Hesse & J.-P. Rodrigue, 2004). It is only when goods fail to arrive or handling or speed or cost become factors that customers are aware of that one might expect a consciousness of the nature of goods transport. The most intimate contact the public have with goods transport may be when trucks slow traffic flow on main roads. For the rest of the time there is an incessant movement of goods towards the consumer without much concern or consideration given to the logistics and distribution processes. Roads are built, logs move to wharves, and fertiliser moves to farms. Of this activity the transport focussed International Road Transport Union (IRU) is far more explicit about the social value underscoring the relationship between economic and social development, and transportation when it says:

In today's globalised economy, professional road transport is no longer merely a mode of transport but has become a vital production, distribution, and mobility tool, driving economic, social, and environmental progress throughout the world. Through its unique, door-to-door goods transport services, road transport drives trade by interconnecting every business to all world markets and is thus crucial for economic growth and competitiveness.

("IRU-ETF Statement on the economic crisis," 2009)

By describing transport as 'driving economic, social and environmental progress throughout the world' the IRU indicates that transport has the potential to shape a community, a country, and the

relationships between countries. Transport here is described as ‘driving progress’; a description that identifies how central the movement of goods and energy is in the production and distribution of goods in a globalised economy. Transport’s central role in trade is quantified in the tonnages, distances and timeframes that are now common place but were not possible before the energy of oil (as a high-quality fuel) powered engines. The exponential change in the capability and capacity to move goods since the time of the first steam engine has increased the reach of trade and commerce. The power to overcome the friction of distance when coupled with advanced communication and navigation capability makes transportation easy and opened its application to a range of innovative uses.

Topical at the time of the commencement of this thesis were several reports written between the year 2000 and 2010 that made predictions about future goods transport behaviour (ARA, 2006; Bolland, 2005; H Mackie, Baas, & Manz 2006; Paling, 2008). The most specific report with a freight focus was prepared by TERNZ, a transport engineering and research company, and that report predicted that on current trends the number of tonnes moved per kilometre of road transport will double by 2020 (H Mackie et al., 2006). The prediction was made with the caveat that ‘there are a number of factors that may cause variation from these predictions’ (2006, p. 3) and estimates being based on a ‘business as usual’ (BAU) model. The methodology used is mathematical extrapolation, and reductionist and the caveat raised questions about the assumptions and nature of the factors chosen, and the link to economic activity.

When I previously worked in the freight transport industry² the relevance of freight movement as an early indicator of economic performance was observed by those I worked with where variances in freight volumes correlated to trends in GDP that lagged by three to six months. This phenomenon turns out to be generalised across the industry and reliable enough that it now has the status of an economic indicator reported as the ‘Truckometer’ by the ANZ bank (ANZ, 2016). That there are links between movement of freight and economic performance suggests that a determinate economic function exists. The correlation as observed is shown in Figure 3 and holds for both increases and decreases in GDP. The measure is consistent with a narrow definition of freight as an economic factor of production, of time and cost per movement. Similar frames of reference appear to apply to all freight transport consideration, with freight movement being treated primarily as an applied science ‘problem’ of efficiency and an economic factor ineluctably constraining future economic growth. The size of growth can be addressed by predictive modelling of freight including predictions

² Seventeen years working in a variety of quality systems, transport strategy and line management roles.

about the contestability of growth between different transport modes (H Mackie, Baas, & Manz, 2006; H Mackie et al., 2006). What we can say about this research is that based on previous performance, this is what will happen given the BAU assumptions of the model. However, the modelling provides little insight into the range of behaviours of the drivers of the increased freight demand, or insight into how

the relationship with the measure of real gross domestic product (rGDP) may change should assumptions be found not to hold should circumstances change. Mackie et al.'s work predated a subsequent TERNZ Foundation of Research, Science and Technology funded project

entitled "Optimising Freight" which addressed two

questions. They are: 'What are the national and regional determinates of freight?' and: 'What initiatives are likely to have the greatest impact on managing freight demand in the future?' The MOT wanted this information to develop a road freight model suitable for use in policy development, and for it to be based on volumes of primary, secondary, and tertiary freight carried through distances within and between each region, and to ports. As part of the research team I attended a meeting³ at the Ministry of Transport (MOT) to present the proposed direction of our research on this. As discussions progressed it became clear that the type of report the MOT was seeking was a formalist mathematical model that makes predictions. I used part of my presentation time to raise a number of other possible factors that may provide insights into future demand, such as oil availability and price, geopolitical power shifts and the likelihood that economic drivers of the past will not be the same as those for the future (Upton, 2008). By contemplating that the future of freight demand may be influenced by a system characterised by resilience, redundancy and retroversion, my speculation was considered 'too discursive' and of limited interest as it was not based on mathematical modelling (Upton, 2008 a personal recollection). The implication was that

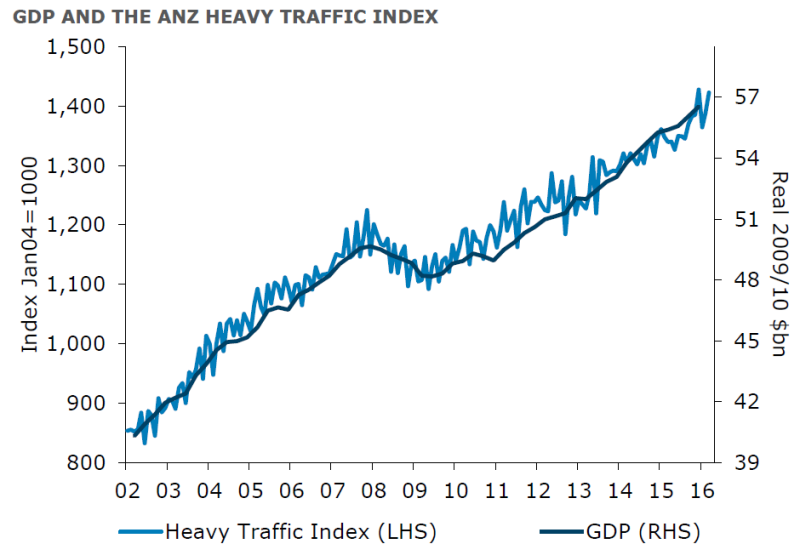


FIGURE 3 RELATION BETWEEN GDP AND FREIGHT MOVEMENT
SOURCE: (ANZ, 2016)

³ Held in Wellington on 21 July 2008. Present Peter Baas (TERNZ) and Joan Smith (MOT)

the only useful way to explain and understand transport is through a link to other equally mathematically modelled reductions of economic activity.

Returning to TERNZ's freight growth forecast, they are based on a ratio where every unit of economic growth generates about one and a third units of freight growth (Baas, 2007). Consequently, extrapolating previous GDP based growth produces a linked volume of freight growth. The predictions made this way for New Zealand are consistent with a number of similar international studies (Ahman, 2004; Dennis, 2007; Kveiborg & Mogens, 2006), and so provide a basis for the construction of more transport infrastructure- notably in New Zealand's case, 'roads of national significance' (Government, 2013). That freight growth outstrips GDP presents transport economists with an econometric problem of whether expected transport growth can be somehow decoupled from economic growth, and rallied calls for greater efficiency, mainly in terms of fuel efficiency. There is a large body of international literature dedicated to decoupling transport from economic growth (Lehtonen, 2006; McKinnon, 2006; Tapio, 2004), with Leung providing a good summary of this in her literature review of transportation and economic development (Leung, 2006). The literature is inconclusive as to whether meaningful decoupling can occur or whether economic development and transport growth can be other than directly related (Ballingall, Steel, & Briggs, 2003) and the means to decouple transport growth has yet to be found. The strength of the linkage suggests that transport systems and economic systems have similar causal and structural bases, but an approach focussed on understanding the underlying mechanisms has not been fully investigated. Research into factors affecting decoupling instead address economic issues, and one factor that is missing from analysis is the role, or impact or significance of energy flow through economic systems and by association, transport systems.

The way freight transport is modelled may be mathematically satisfying and politically comforting, but the findings seem to be self-referential and limited answers to why freight moves. Transport metrics in economic models gives little weight to broader matters such as the type and quality of energy used for transport and its ongoing availability and price, or the efficiency and environmental impact. This is a highly anthropocentric view of transportation, and one that has dematerialised in its theorising and become less considerate of geographic and topographic factors and more focussed on economic modelling in pursuit of economic growth. This turn in methods of transportation studies changed mid-20th century when geography experienced the 'quantitative revolution', and the through the influence of economic theory (Burton, 1963) and lead to work such as factor-analytic studies of the connectivity of a transport network (Garrison & Marble, 1964). The

result is a disconnect between theoretical and empirical approaches, where ‘concordance to reality became somewhat secondary; realities were made to fit into models’ (Rodrigue, 2013).

Rodrigue identifies the change but still classifies transportation as a field of enquiry and application disconnected with realities best addressed by more focus on current methodologies. He situates transport study as a performance driven activity found within the interdisciplinary activity of planning, geography and engineering projects and research about movement technologies and the facilitation of infrastructure development where methodologies vary with each field of inquiry and application (Rodrigue, 2013). Rodrigue describes current research as addressing what he says is the specific purpose of transport is to fulfil the demand for mobility, by acting on existing information about the requirement to move freight and people around (Rodrigue, 2013). A summary of this way of constructing the goods transport ‘problem’ confines theorisation to the management of reactive processes where transport only exists at all when in pursuit of a specific purpose and executed within the constraints of the time of development (Glaeser & Kohlhase, 2003).

The way transport is researched is closely linked to the metric that 98% of all goods transport is powered by engines that burn fossil fuel. This reliance by goods transport on high quality energy is not however a major factor in economic evaluation that is often simply characterised as activity measured by movement and time. There is little reference to the materiality of distance travelled or the real value of fuel usage. However, while energy consumption can be mitigated at the margin through efficiency improvement, any future high-quality energy resource shortages will impact heavily on the current economic growth requirement where transport ‘tonne-kilometres’ will continue to increase. For these and efficiency reasons a strong economic imperative to find ways to ‘decouple’ freight transport growth from industrial growth.

There are studies that address the impacts resource, economic and political disruption on transport systems and an example is the second National Freight Demand Study was released in 2014, and that report included the by-line ‘ensuring our transport system helps New Zealand thrive’ (Paling & King, 2014). The report identified drivers and impacts that have or may have an impact on the freight task in New Zealand, such as international events like the Global Financial Crisis, and the growth in volumes of the land base production of logs, timber, and dairy products. Shipping patterns and distribution systems have become more sophisticated as exports increase and researchers noted a ‘growing desire to apply environmentally sustainable solutions to the movement of freight, which has encouraged a shift to rail’ (Paling and King, 2014, p3). The decision to allow larger trucks on some major transport routes is also noted in the report and they are referred to as ‘High Productivity Motor Vehicle (HPMV)’ and are credited with increasing efficiency

and reducing costs. The report reviews the overall modal forecast and finds that in 2042 New Zealand will have a similar modal split to 2012 with 91.5% of freight travelling by road freight, and with all three modes increasing proportionately, as based on the TERNZ forecast. This is a strong statement of BAU methodology with little expectation of a major change in transport patterns.

2.2 Dominant Transport Research Themes

Transport is studied by a variety of disciplines with different interests and perspectives and this is reflected in the research themes that dominate the transportation discourse. Much of the research is focussed on the social (e.g., mobility) and environmental impacts (e.g., pollution), often linked to information and communication innovation. Advances in information technology continue to be applied to supply chain performance and the related measuring and monitoring of energy efficiency and use. This type of transport research provides engineers, financiers, geographers and planners, and economists with structural, spatial and economic challenges for which they can ply their human resource skills (Hibbs, 2000). Hibbs notes that there is no consistency in the way that transport issues are thought about and holds that it is the weakness of discrete 'models' of transport across the disciplines that has inhibited the development of a unified theory of transportation (2000, p23). Hibbs' focus is on the application of trade skills to problems that happen to include movement of goods. There is no need for any deeper understanding of transportation. Predictive attempts continue to be made to plan for future needs, particularly for infrastructural development to cope with capacity increases.

In their literature review on the social and distributional impacts of transport Markovich and Lucas (2011) report that while transport has social impacts, there is less attention to policy matters relative to the focus on economic and environmental impacts. They found a lack of academic and policy attention in research that is fragmented and carried out across several disciplines. One of the gaps they identified was the lack of a standardised set of methods for such study, and that the knowledge base 'is currently fragmented across numerous disciplines, including: spatial planning; human geography; social policy and sociology; public health; engineering; and of course, transportation; each with their own dominant approaches and methodologies' (2011, p. 10). This is like what Hibbs found and reinforces that quantitative methods are favoured over qualitative ones with 'a somewhat narrow conceptualisation of transport's distributive effects' (2011, p12). They concluded that further work is required to frame transport issues and that the impacts of transport have been historically underestimated. The reasons for this include the way research is conceptualised differently across several disciplines. The diverse findings are difficult to quantify, and to effectively express in transport policy and these issues are often assigned low priority.

(Markovich and Lucas 2011, p41.). Their literature review found that the impacts of transport to be largely negative, and affected parts of society in different ways, and have a span of impact from households, to national levels and inter-relate with other transport issues. While not specifically about freight transport, their research indicates that the social meaning and impact of transport is not well theorised about how changes to transport impact society. Of note is their specific recognition that the span of impact is at different scales.

Current freight transport research within New Zealand primarily supports efficiency and the role of transport in supporting economic growth as shown in research funding reports (Government, 2009a). At an international level attention to goods' movement and freight distribution are found to be 'widely underrepresented in regional science and geographical research' (M. Hesse & J. Rodrigue, 2004, p. 1). They argue that freight transport is not just a derived demand and transport science studies focussed on transport capacities, economic issues or trade aspects is an impoverished view. They note a change since the 1990s, which they describe as 'looking through spatial lenses' at the interdependence of physical distribution and materials management and the location and shaping of freight traffic flows and logistics facilities. (M. Hesse & J. Rodrigue, 2004) call for further empirical investigation to improve understanding of freight and distribution, and how physical space is interwoven with informational structures. Specialisation and concentration have increased physical distances from markets to consumers, with transport systems becoming strategic supply chain infrastructure in a drive to reduce total systems costs. In this way transport is recast as part of a strategy of production and a means of avoiding capital investment, and so performs a new role in minimising capital expenditure by optimising commodity and supply chains. An example of how this is happening is the innovative use of containerised freight to reduce the need for warehouse space at distribution points. By using Just-in-Time planning tools, freight distribution can bypass commercial infrastructure with freight effectively warehoused in motion, by extending the functionality of the container to that of a warehouse. A second example of transport as a production strategy is the way that milk tankers are deployed as mobile pipelines that replace local production facilities. For several years milk and cream were transported out of the Nelson, Marlborough, and North Canterbury regions to production facilities at Clandeboye near Temuka in South Canterbury. the round trip to deliver 30,000 litres involved distances of at least 1000 kilometres. but provided a strategic solution that saved expenditure on factories or pipelines.

There is a lack of clear narrative explaining how goods transport is theorised in the current period of globalised industrialisation and the free movement of capital. The changing role includes the transformation of goods movement that containerisation brings as central to enabling the macro-

economic, technical, and operational and governance factors that have changed freight transport. What is clear is that some developments add complexity and flexibility to the technical aspects of transport processes, but continue to perceive freight transport systems only as a consequential demand derived of other processes or as a mere “space shrinking” function’ (Notteboom & Rodrigue, 2008).

A second area that Notteboom and Rodrigue call for future study concerns the increasing amount of energy and land that freight activities are consuming. This is the only time energy is mentioned in their analysis of transport geography and freight distribution. They also call for theoretical considerations so contemporary change is understood more comprehensively, however, this is called for mainly within an economic framework.

Logistics management and the integrated management of supply chains broadens the range of activities that constitute goods movement across transport networks. The objective is to minimise the overall system cost as low transport costs enable commodity chains to increase its global reach. Within this framework transport is situated within wider networks. One approach that uses an analytical tool to understand this is Networks Employing Transport Systems (NETS) (Tiffin & Kissling, 2007). This study of commodity supply chains as complex structures recognises that goods movement requires high inputs of high quality energy and are hydrocarbon dependent. Their work integrates ‘commodity chains technology’ into economic measures of transport as a function of time and money and the expansion of markets central to maintaining growth.

A feature of supply chains is their ability to respond to exogenous pressures coming from economic, social, and environmental quarters. Brian Plested, founder, and chairperson of Mainfreight Ltd. says that as an industry, freight movers survive by being reactive to market changes, and not as the developers of new models (Plested 2008 pers comm). This implies that a company’s performance is not measured in absolute terms, but in relation to the performance other suppliers of similar services. Cost, time, and quality become relative, with changes in cost passed on to customers and quality and service becoming harmonised across the industry. As an industry group the response is to be efficient competitors, in the one employment market, compete as an oligopoly, and offer limited modal choice. The risk management of social variables is achieved through adhering to national safety standards and highly regulated road use. Logistics operators distribute using road, rail, and port infrastructure, and move goods as required by business, with no input into the equity of the transport infrastructure accessed. Environmentally, as hydrocarbon users, while there can be some efficiency control there is no direct control over factors of climate change, noise, land use,

biodiversity, and waste (CO₂). In summary, commercial transport makes the most of the opportunities and constraints of an existing systems.

The nature of goods transport cannot be properly understood without reference to the role of communication. In the foreword to Tiffin and Kissling's (2007) book *Transport Communications*, Peter Rimmer, a professor of economic geography and transport economics, identifies that they are the first to explain the vital link between transport and communications in modern business. My research took its direction from Tiffin and Kissling's (2007) explanation of the vital link between transport and communications in relation to globalisation, suggesting that transport as 'action' and communications as 'perception' constitute part of the one process (this is explored in chapter 4). The starkness of this situation is reflected in the separate running of transport and communication conferences and research reported on each in separate journals. This is symptomatic of the lack of integrated theorising about goods transport. Making the transport and communication link explicit provides a research waypoint that opens the possibility of a deeper understanding of spatially and temporally coordinated behaviours enabled through goods transport and where perception and action are coupled as part of the one process.

The importance of a perception aspect of communication is informed by Gibson's (1979) physical theories of perception and action. James J Gibson was an American psychologist whose interests were in the field of visual perception, and ecological psychology. He argues that living things as 'perceiver actors' are part of a bigger picture that includes their environment as one dynamic system. He claims a commensurability between the properties of living things and physical things can occur without additional cognitive construction or processing (Swenson & Turvey, 1991). Gibson describes the basic relationship between transport and communication in terms of "we must perceive in order to move, but we must also move in order to perceive" (Gibson, 1979, p. 223) and specifically for living things not trapped by their food source, "we move to eat and we eat to move" (Swenson & Turvey, 1991, p. 319). Living systems are characterised by physical mass which is usually an energy rich food source moved through space and time and across one boundary to another. While living systems can store the energy transported in goods, the act of transportation itself always results in entropy. Transport within action and perception processes is a beneficial act when the energy gained, for example in food, exceeds that expended in the gaining of that food.

2.3 Transport research and policy

In 1996, Maurice Williamson, the then Minister of Transport rhetorically asked what the view for land transport will be in 2010, or ‘even further out, say the year 2025’? (Williamson, 1996, p. 1). He asked, “what role does the Government have in land transport, both now and in the future?” (1996, p1). It is a question that has no clear answer within New Zealand politics to this day. The last New Zealand Government’s broad policy direction for the transport sector was called Connecting New Zealand and set out plans for ‘an effective, efficient, safe, secure, accessible, and resilient transport system that supports the growth of our economy in order to deliver greater prosperity, security, and opportunities for all New Zealanders’ (Government, 2014a). In the foreword, the Minister of Transport said that moving goods efficiently is ‘vital to speeding up economic growth’ (p5), and so the governments object for transport is that it is a resilient system that delivers greater prosperity, security, and opportunities. The policy paper recognises the road network as the backbone of the transport system and that 70% of all goods moves by road (Fig. 4). A renewed focus on transport as ‘support for economic growth’ began with a significant improvement programme in 2009. In 2008 \$36 billion was to be invested in roads over the next decade. The strategic direction for land

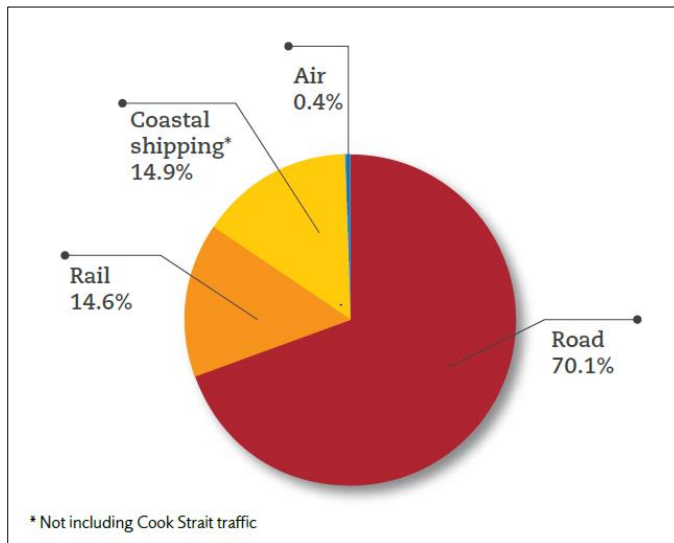


FIGURE 4 FREIGHT MOVEMENT BY MODE
SOURCE: NZ GOVERNMENT, 2014. P7)

transport was economic growth and productivity, road safety and value for money (Government, 2014b, p. 4). Challenges for goods transport in New Zealand are recognised as distance from international markets, volatile fuel prices and logistical problems that a doubling of goods moved over the subsequent 30 years. The report also anticipates additional costs in response to international concern over greenhouse gas emissions. The report expects New Zealand’s freight task to

grow by 58% in tonnes by 2042, with road transport expected to account for 70% of that (Government, 2014b).

The role and deployment of infrastructure is the focus of a Ministry of Transport 2025 strategy project. As part of that process a review considered ‘regulatory approaches commonly used in developed economies’ (Meade & Evans, 2015). The reasons why regulation might be required

include control of market power, third-party costs (externalities) and people acting in apparently 'irrational' ways ("cognitive biases") (Meade & Evans, 2015, p. 1). The report says that 'general rules to protect competition complement and sometimes substitute for industry regulation, as do alternative forms of ownership' (2015, p.2). Regulatory trends include ways to replace 'command and control' mechanisms which are seen as informationally demanding, costly and distorting, and replacing them with incentive regulation that encourages firms to use their private information to reduce costs (Meade & Evans, 2015).

Neither the Government Policy statement nor the research strategy use the word 'sustainability' with reference to transport from 2009 onwards. This contrasts with the NZ Transport Strategy 2008 (MOT, 2008) that contains objectives to ensure environmental sustainability through the limitation of greenhouse gas emissions and consideration of resource use and local environmental effects. The first NZ Transport Strategy in 2002 set out a vision to have 'an affordable, integrated, safe, responsive and sustainable transport system' (MOT, 2008, p. 2) and set out to provide direction over the next 30 years in line with the 'government's sustainable development, energy and climate change agendas' (p2). The words sustainable or sustainability appear 48 times in the strategy document. It seems that transport policy is divided along party lines with no underlying agreement on what is going to be good for New Zealand on the medium to long term.

The political influence extends to the way the dendritic role of transport is viewed in a productive economy. O'Brien, a transport commentator, defines infrastructure as the means by which land transport happens (O'Brien, 2008) and that includes infrastructure employed by roadways, railway, airway and seaway. O'Brien observes that the NZTS and the National Rail Strategy do not deal with infrastructure – documents both written under the preceding Labour-led Government whereas the National-led Government's GDS 2010 focuses upon infrastructure provision both as the target for spending and for the funding of research into the engineering aspects (such as the tensile strength of concrete). O'Brien posits that the Government is relying on overseas research that describes a high correlation between the provision of infrastructure and economic growth as guidance for its transport policy.

In 2009, the Minister for Infrastructure described the concrete and mortar approach as a step 'towards the first national infrastructure plan' (Government, 2009b) in terms of 'Building Nations'. However the initiative to 'build a nation' is ideologically different from the actions of New Zealand's historic nation builder behaviours as described by Easton (2007). What is different is an apparent over commitment to economic growth as a race against Australia, to build our way out of economic performance problems through the pursuit of efficiency that better road networks. For this thesis

the time frame is not critical, but for the purposes of a realistic or at least conceivable period of transition transport infrastructure is often considered to have a lifetime of at least thirty years. For context the policy of a mayoralty for the district of Tasman in the South Island of New Zealand, one candidate campaigned on the need to develop a *five-hundred-year* plan. Within that timeframe, Soddy's century old concern about energy use central to transport are topical, and reports such as The Limits of Growth (Meadows, Meadows, Randers, & Behrens, 1972) would be classed as breaking news.

The New Zealand Institute of Economic Research (NZIER) report on sea freight scenarios addresses the question of how policymakers act to ensure an efficient sea freight market, and find that any move away from a competitive market is 'likely to act as a drag on the New Zealand economy and reduce GDP' (Nixon, 2010, p. 29). The Minister of Transport said that the report supports an industry-led approach and welcomed the report's findings as 'consistent with the government's view' (Joyce, 2010). He said, "Attempts to pre-empt future likely market developments are unlikely to produce better results for the economy, with the government's best role being to "ensure the right price signals are in place and land-based infrastructure, such as roads and rail can meet the needs of the freight industry as it evolves"(Joyce, 2010). The press release ends by saying that "attempts to pre-empt future likely market developments are unlikely to produce better results for the economy" and notes that the report "adds to the debate about maritime transport and I look forward to further discussions with the industry to reach a common understanding of its likely future" (Joyce, 2010). This is reinforced in the policy direction document where it is restated that the best approach for government is 'to leave the final decisions in the hands of shippers and let ports react to those with their own investment decisions' (Government, 2014a, p. 39) From this it is clear that the current focus on freight transport policy to do more of the same faster and more efficiently whereas, as Galbraith wrote in his book *The Affluent Society* 'that the conventional wisdom having been made more or less identical with sound scholarship' (Galbraith, 1958, p. 9) it appears in this case that market forces are considered 'sound scholarship' . Responsibility for connecting New Zealand with world markets has at this time the government's role to ensure the right price signals are in place for road and rail infrastructure to meet the needs of the freight industry as it evolves (Government, 2014a). Since 2008 the Ministry of Transport has issued about fifteen strategic document and research reports none of which are critical of this approach.

The policies of many other countries continue to show concern for transport and sustainability. The international Transport Forum's key Messages from Ministers, regarding freight (OECD, 2011) emphasised the vital importance of goods transport for enabling economic growth while at the

same time recognising that there is a complex challenge in meeting society's demand for high quality transport, while simultaneously reducing the adverse impact of transport on climate change and air quality, human health and the natural environment. The paper calls for a sustainable and efficient logistics and freight transport system, able to meet the demands of economic and traffic growth. Better infrastructure, wider roads, longer tunnels and better bridges are given as solutions to reduce the costs of geography. Consistent with NZ transport network objectives, there is a push internationally to get more movement on existing structures by employing better information and technology as logistics, and to keep costs per tonne/km down by more efficient engines to move goods. The report also hopes there will be a decoupling of the cost of transport from the cost of goods movement and so somehow address the statistics that show that for every unit of economic increase, there is 1.3 units of transport increase.

The New Zealand Transport and Research Strategy 2016-2020 (Government, 2015) has as its goal:

To create a research environment with the capacity and capability to ensure transport research maximises economic and social benefits of the transport system and minimises harm.

The goal of the strategy is to create a research environment to ensure that research maximises economic and social benefits and minimises harm. The long-term outcomes are given as effectiveness, efficiency, resilience, safety, and responsibility. For transport the government objectives cover growth, infrastructure and efficiency and conservation where the transport system goal is to ensure the efficient movement of goods 'from the farm gate' to overseas markets. The infrastructure plan focusses on ensuring better use of existing infrastructure and for new investment to meet long term plans. The aim is for transport is to become more efficient, with greater diversity of fuels and alternative energy technologies.

The research strategy has a strong focus on asset management and safety. In response to the perceived fast-moving environment, research is to focus on knowledge gaps of strategic importance with an expectation of potential synergies being found between public and private sectors, and across health, environment, social and economic sectors. To achieve this, the strategy aims to employ common methods to guide research development and prioritisation, and co-ordination between researchers and users of transport research. Potential research themes are summarised as follows:

Effectiveness	Effects of interventions and transport performance on economic performance
	Whole of the journey travel patterns and responsiveness to changes
	Effectiveness and behavioural responses to legislative and non-legislative measures (including safety)
	International standards and compatibility of technologies
Efficiency	Measuring and comparing transport performance by intervention (including land use and transport provision)
	Users' willingness to pay (including Value of Statistical Life)
	Freight efficiency (e.g. fleet utilisation, barriers and opportunities of technology adoption)
	Understanding who pays a cost and who benefits
	Understanding economic and social impacts of user charging
Resilience	Better understanding resilience and emergency management at a strategic and system level
	Understanding changes in transport demand (including modelling of active modes)
	International labour market trends and transport
	Future changes in workforce capability and capacity
Safety and Responsibility	Implications of technology on provision and use of transport
	Risk exposure, behaviours, outcomes and interventions
	Social impacts of transport (including travel decisions, impediments to access, distributional impacts and infrastructure requirements)
	Better understanding life cycle environmental impacts of the transport fleet (including all modes)
	Life cycle emissions of emerging transport technologies

FIGURE 5 DRAFT TRANSPORT POLICY RESEARCH THEMES

(SOURCE: NZ GOVERNMENT, 2014. P7)

Active research projects are to cover economic development, activity management, integration, safety and demand management and performance management. However, there are no active research projects listed under the heading sustainable land transport. Projects with some connection to freight transport include work by Ernst and Young Transport Advisory Services Ltd on the value of resilience, and ECPC Ltd on the economic impacts of connectivity. There was (in 2010) no other active research concerned with goods transport. The LTSA web site database lists one research report with a freight theme out of the 581 reports completed since 1991, and that was on the topic of barriers to supply chain innovation. There are forty reports for the same period on the theme of sustainable land transport with none of them covering the topics of this thesis.

The politics and practicalities of oil use and availability is at the centre of all goods transport systems. To meet the growing demand for oil the world would need to add roughly the equivalent of Saudi Arabia's current energy every seven years (JFCom, 2010), with oil and coal powering the energy train. Harvey (2005) notes the importance of Middle Eastern supply as 'the spigot of the global economy' and its control as being very significant in terms of energy security. A point may be reached where further expansion of oil production becomes impossible because new production flows are fully offset by production declines. Campbell summarises the importance of understanding the implications of a decline in cheap oil-based energy because of its role as the principal driver of economic growth. He says that the lending that banks have made against future expansion will be undermined and lead to fewer long term investment opportunities, which he believes could lead to a significant depression (Campbell, n.d).

Hallock et al. (2004) calculate that the number of net exporting countries will be reduced from 35 (in 2004) to between 12 and 28 by 2030. Of growing importance on the supply side is that exporting countries are increasing their domestic use of oil which will further reduce oil for export as shown by the example of Saudi Arabia's increasing use of burning of oil such as the plan to fuel a \$24 billion dollar desalination plant expansion programme between 2015 and 2020 (*The Report: Saudi Arabia 2015*, 2015). Jesse and Linde (2008) found that most supply constrained scenarios are likely to last much longer than policy makers anticipate and believe oil supply constraints will last for the next decade.

The Draft Energy Strategy (MED, 2010) recognises New Zealand's vulnerability to increased oil prices and to external disruptions in oil supply and the reliance of imported oil 'for around half our total energy needs, including almost all our transport needs' (MED, 2010, p. 13). Also acknowledged is that oil and gas are critical feed stocks for industry and for fertilizers use to sustain and increase agricultural production. The report refers to a ninety-day reserve to cover 'serious international oil

supply disruptions' but doesn't include the fact that the reserve is not held within New Zealand, but in Holland. Regarding the uptake of alternatives, the report indicates that the government's role will be to 'stimulate new market developments or remove barriers where appropriate'. The ultimate uptake of new energy sources and technologies it says 'will depend on the decisions made by consumers' (MED, 2010, p. 13). The stance that appears to have been taken by the government is on that a WWF-New Zealand campaigner called a 'do nothing' approach and whose organisation's polling on the energy strategy reported that the majority of New Zealanders would prefer a more active approach (WWF, 2010). While there is interest and debate around efficiency and security there is little in the literature that explicitly recognises that the most important of all forces driving globalisation is the constant and increasing flow of hydrocarbon energy that both a scarce resource and one that is under-priced relative to other energy flows. The general relationship between flows of energy, economic systems, and perceptions of the cost of transport defines the spatial limits of a goods system. There is some recognition of this at central government level as "Key export-generating industries in the New Zealand economy including tourism and timber, dairy, and meat exports are very vulnerable to oil shocks because of their reliance on affordable international transport" (Parliament, 2010, p. 21). Oil shocks and scenarios of energy shortages appear to remain outside the current market driven transport developments in New Zealand.

In 2006, Shell narrowed down possible responses to shortages in two simple long term energy scenarios and named them "scrambles" and "blueprints" (Shell, 2006). The descriptions equate roughly to situations of chaos and cooperation. Scrambles describes where "Nations become concerned about energy security and grab resources wherever they can get them. Governments quickly react, and they react sharply." Shell supported the more optimistic cooperative option relying on a government led collaborative approach that sees countries working towards carbon trading, global efficiencies on resources and dealing with carbon dioxide.

Others have expressed the view that the process of reducing the amount of oil used in the economy will need to start with private transport as half of all oil consumed is burned as motor fuel (Rubin, 2009). Rubin also notes that economic development always follows the transport routes 'just as water always follows the path of least resistance' (2009, p. 248). He says that the way transport systems are designed will dictate the type of town that will develop in the future, with an example being small cities and commuter villages as nodes to local agricultural production – with a local flavour. This places emphasis on the importance of the choice of transportation options in situations where transport is limited by energy supply, as it would strongly influence future social structure and is a scenario yet to be experienced in the post-WWII period (at least not in New Zealand). The

development over the last one hundred years of an oil-based economic and transport system has required significant investment in infrastructure that is all predicated on continuing oil driven growth. A report published by the US Department of Energy, also in 2005, concluded that without a crash programme of mitigation instigated 20 years before the event, the economic and social impacts of an oil peak would be “unprecedented”. When the impacts of a peak oil scenario are considered, preparation needs to commence now given even the brightest scenario for oil supply, stagnation, or depletion. The report summarises the situation as: ‘While it is difficult to predict precisely what economic, political, and strategic effects such a shortfall might produce, it surely would reduce the prospects for growth in both the developing and developed worlds. Such an economic slowdown would exacerbate other unresolved tensions, push fragile and failing states further down the path toward collapse, and perhaps have serious economic impact on both China and India.’ (JFCom, 2010). It is reasonable to take from this that a static or declining oil supply scenario could radically change systems behaviour, or at least change the way growth occurs.

The central theme running through the twentieth century an attempt to explain goods transport using ‘theoretical arguments developed in economics’ (Gregory, Johnston, Pratt, Watts, & Whatmore, 2009, p. 376). The theories of Weber were revisited in an attempt to explain ‘the seats of industry’ using the tools of neoclassical economic theories of maximizing behaviour and rational choice. From the 1990's Neo Classical economists again applied theoretical rigour, analytical methods, and statistical techniques to the space-economy. Sachs typifies the epitome of this line of enquiry when self-reflecting on his contribution as an economist in a globalised world. Referring to his time as a World Bank adviser, he recounts a discussion he had with David Morawetz, who described Bolivia as a land locked country with high transport costs (Cassidy, 2005). He explained that as a result it succeeded in only exporting high value to weight ratio products such as silver tin and cocaine. Morawetz pointed out that lower value goods were not worth exporting because it cost too much to get them to market. Of this discussion, Sachs recounts;

"Morawetz's point about Bolivia's geographical distress was truly (and incredibly) something new to me. In all of my training, the ideas of physical geography and the spatial distribution of economic activity had not even been mentioned."

(Cassidy, 2005)

That Sachs by this time was a Professor of Economics and had worked for at least three years with South American countries to ‘improve’ their economies again shows the insignificance currently placed on the physical world that transport systems negotiate all the time. As the population grows the economic interpretation of space is conveyed as a narrative where the physical world is

somehow shrinking. What such a representation appears to imply is that the economy and [anthropomorphic] role of humankind is the reality, and 'god-dammit', the earth is now hindering progress. An (unfortunately) false assumption is that real freight rates also reduce because of the shortening distances between producers and markets, confusing distance with time and cost. The underlying but unstated assumption in this type of geographical theorising is that the physical world is indeed a separate entity to the economic world that is ever expanding as new opportunities are thought up. During this time 'a new methodological sensibility, critical realism became the unofficial methodology' of industrial geography (Gregory et al., 2009).

A report by the consulting company Charles River on market power and its effect on port efficiency is aggressively critical of local politicians' 'interference' with international freight issues (Government, 2002). Charles River's preferred political economic structure is through centralised control by economically informed business professionals – presumably trained in economics - who, they say, can better understand the purpose and function of regional port structures. The report reflects an underlying view that the market and economists' views are the way to steer development, particularly the demand side pressures of international shippers. The government's role in this scenario they say is to not allow business to lead development. From a systems perspective this view requires no border management by government and is consistent with the liberalising aims of the economy begun in 1984 which brought about a change to less government intervention regarding border protection (Easton, 1997, p. 13).

Using refreshingly non-economic terminology, Dryzek describes transport 'as a raw interface between human systems and ecological problems' and as such provides 'the means that societies choose to make collective choices that have all kinds of ramifications' (Dryzek, 1987). In terms of its social effects, HT Odum groups transport and advertising together and calls them energy inefficient growth priming activities that have a place during rapid expansion and growth, but are destructive in a stable system as their special costs exceed their energy use (Howard Thomas Odum, 1974). A transport framework is a mechanism that Dryzek says will 'strongly affect the kind of world that exists or develops'. If, as he says, transport is at the interface between human systems and ecological problems, then the framework must have the capacity to handle ecological problems. The oil shocks of the 1970's highlighted the new and growing connectedness between nations of the world as complexity increases. Hesse & Rodrigue address the level of complexity now found in logistics and distribution and say that economic growth is highly dependent on growth in fossil fuels and we cannot assume that the growth rate can continue. There is a growing problem in the balance between depletion of supply and technology of efficient use especially where there is a

diminishing energy return on energy investment (EROEI). It is significant that he says 'our existing economic approaches and theories are completely inadequate for understanding this situation' (M. Hesse & J. Rodrigue, 2004, p. 180).

Freight transport increases and climate change share a similar problematique, with the super wicked problem of climate change where there is a focus on pollutants, and where transportation is a major polluter. Lazarus contends that a suitable institutional framework does not exist to address spatial and temporal issues for climate change and this also applies to transport (Lazarus, 2009). The absence of global law-making institutions with jurisdictional reach and legal authority fails to match the scope of the problem as expressed by Hesse & Rodrigue above. For goods transport this is also true, with transport within New Zealand at the mercy of international trends and change. Lazarus argues that when climate change is considered as a systems problem the resolution of the causes, are unsolvable within a neoclassical economics framework, Part of the problem he says is that the parties who are in the best position to address the problem are those who also support the levels of activities that cause it, and so have little incentive to act within a short time frame (Lazarus, 2009, p. 1153). He also gives as a reason the 'absence of an existing institutional framework' to tackle the spatial and temporal scope of climate change.

Marc Levinson, an economist, historian, and journalist who specialises in trade, transportation and energy identifies the reasons that business and production activity nodes form is linked with the extraction and transport of raw materials. He does not connect energy flow with the process of organisation of social systems per se but does attempt a connection between. Evolutionary processes and transport systems. While he does not consider energy flow as an organising process as such, he does find that network evolution models offer insights into processes previously 'thought to result from the visible hand of planners, engineers, and politicians' (Levinson, 2005).

The *International Handbook on Transport and Development* contains research that explores the relationship between transport and development and the current and emergent thinking about the impacts of transport on urban structure (Hickman & Banister, 2015). Interdisciplinary perspectives are considered in the context of increasingly sophisticated analysis and a perception that effective integration of transport and development remains poor in theory and practice. The focus of this research is the way different means and systems of transport are related and can change land use, and how transport influences the economy, environment, social equity and well-being' (Hickman & Banister, 2015, p. 4). The Handbook describes the way transport is approached by planners and the effect infrastructure has on wider social issues, and on cultural factors including the sociology and psychology of travel. The handbook consists of forty-five chapters in which the editors address

these issues in three sections covering urban structure and travel; transport and spatial impacts; with a fourth section addressing the wider dimensions in transport and development (p4). In part four a chapter by Ole Jensen, Professor of Urban Theory who is a planner with interests spanning urban motilities and urban networked technologies. He questions whether transport is just 'derived demand' or a 'journey from A to B' through addressing issues of culture, habits, norms, and emotions as potential rationales for transport and compares these to the more conventional standpoints of rational choice in movement and matters of distance, time, and cost. Other themes in this section of the handbook consider whether communication means 'the death of distance', the implications of oil vulnerability and personal mobility, along with the need for education about the links between an energy intensive lifestyle and consequential carbon emissions. Schwanen, an associate professor of transport studies and geography considers the dynamics of relationships and identifies future research areas where exploring process as well as place may lead to a deeper understanding of the transport and development field (p667).

Transportation Research is an international journal published in four sections. Part A contains papers of general interest including policy analysis, planning and interaction with political, socioeconomic, and physical environment. Papers address the unification of the field where topics come from the perspective of economics, engineering, sociology, and psychology. Parts B, C and D cover Methods, technology and transport and the environment.

I searched Part A for the following words as they are key themes developed in this thesis:

- 'Thermodynamic' returned eight articles since 1975 of which none covered transport and thermodynamic systems, and the last one was written in 2001 and evaluated alternative fuel vehicles.
- 'Evolution' returned 581 articles, but none that considered transport as an evolutionary process, and searching by 'evolutionary process' was equally unrewarded.

In the foreword to Transportation Science, Hall defines transportation as a discipline that transcends transportation technology and methods where transportation scientists are motivated by the desire to explain spatial interactions that result in movement of people and objects from place to place' with a heritage that includes geography, economics and location theory (*Handbook of transportation science*, 2003),,. Hall says that the phenomena of transport is explained by quantitative methods, mathematical models, and optimisation algorithms. He contrasts the historical transport means by human, animals, winds and currents with today's movements that are propelled by engines, and says that in many respects, 'one might say that transportation modes of

the late 20th century have little in common with their ancestors' (2003, p2), but that the basic tasks remain the same.

Klare, an expert on resource geopolitics, identifies the control and transport of oil as central to the geopolitics of energy and the political means to power, and the shaping of the current century (Klare, 2008). The huge release of high quality energy being released into the world-system environment has changed rules away from natural system dynamics and constraints and so remodels man's place as a both a production and producer 'of an active and dynamic process of terrestrial evolution' (Swenson, 1997a).

Oil powered transport enabled the rise of unprecedented freedom of the individual is contrasted with a breakdown of the social contract undermining structures such as unions, businesses, and government. He says there is a political silence surrounding the unwinding of the structure of society. The changes that Packer is critical about are enabling through lower tariffs and technological advances, along with transport being used to effectively export real economy jobs from most developed nation (Packer, 2013). Levinson has written widely about transport systems including his book describing how containerisation underpins all modern logistics and supply chain systems (Marc Levinson, 2006). In an essay *Freight pain: the rise and fall of globalisation* he describes how cheaper transport, lower tariffs, and technology have turned low-wage countries into workshops serving wealthy markets (Mark Levinson, 2008). He describes the way transport has increased as multinational companies move semi-finished goods between production plants in different countries, using supply lines that are invisible to consumers with such efficiency that critical components are moved globally as part of production systems (Mark Levinson, 2008). He says that the same supply chains can also dematerialise taxation on the finished goods through component pricing being used to direct profits to tax haven countries. It could be said that goods systems develop to serve politically motivated projects, and that has been the pursuit of the accumulation of capital. The result is fast changes to social structure through utilising access to cheap transport systems without a co-commitment to fully understanding or defining governance requirements of the impact of goods movement through monitoring the systems' behaviour, or goods behaviour.

2.4 The influence of neoliberalism on transport and borders

Here's my philosophy. The less government, the more freedom.

The fewer bureaucrats, the more prosperity.

Ted Cruz (Hacker & Pierson, 2016)

In this section I review social, economic and political views collectively known as neo liberalism, and how its rise to prominence is best captured in the phrases ‘there is no such thing as society, only individuals and markets’ and the mute acceptance that ‘we are all neoliberals now’, and most interestingly ‘there is no alternative’ (Monbiot, 2016). The influence of neoliberal ideology is significant in the way transport policy is set and so determines the type of research and the boundaries of current research topics. The influence of neo liberal thinking manifests in the reduction of borders and other barriers to trade and the resultant expansion of international trade enabled by unfettered transportation expansion. The presuppositions of neoliberalism include a pragmatic rational singular mode of action open to social systems summarised as ‘there is no alternative’ (Thatcher, 1980). Ronald Reagan, the fortieth President of the United States of America helped cement the gap between nature and mankind when he said ‘There are no great limits to growth because there are no limits to human intelligence, imagination and wonder’ (Reagan, 1985).

The term neoliberalism emerged from the ideology of Ludwig von Mises and Friedrich Hayek and their concern about the twentieth century development of the welfare state in Britain and Roosevelt’s ‘New Deal’. Ted Cruz, an American lawyer and Senator for the state of Texas, contested the Republican presidential candidacy, and showed the continuing appetite of neoliberalist thinking where he says ‘the less government, the more freedom. The fewer bureaucrats, the more prosperity’. The American rise of neo-liberalism and personal freedom coincides with a thirty year dis-assembling of structures and institutions (Packer, 2013). Neoliberalism’s rise in a time of rapid expansion of transportation where oil is the most significant commodity transported by both volume and value. Oil contains the most energy for its weight and volume of any fuel. These features make it a stable and transportable commodity and securing its supply is geopolitically very valuable for maintaining political power. Aligned with this are the economic benefits of cheap industrial and consumer goods that supported the prize of personal freedom promised by neoliberalism.

The social change brought about by the rise of neoliberalist policies originating in the USA was paralleled by a similar, perhaps more extreme free market version adopted in New Zealand by the 1984 Labour Government under the strong influence the finance Minister Roger Douglas had on the political direction at the time (Jesson, 1999; Kelsey, 2002). While the behaviour of neo liberally inclined politicians may be less extreme in the third millennium than during the heyday of Rogernomics⁴, decision makers who believe there is no other way to operate than by way of the

⁴ The term ‘Rogernomics’ references Roger Douglas’ the reforms carried out with this economic ideology.

rationality of the market now populate the ranks of political and business decision makers. (Jesson, 1999). This has led to thirty years of change to the function and role of state apparatus, favouring the neoliberal interpretation of state, where human welfare is premised on personal freedoms (Harvey, 2005). The liberalisation of 'freedom' condones wealth accumulation and opens up international trade and development leading to increased goods movements in New Zealand and internationally. The concomitant infiltration of neo liberal academics with the political and business interest may explain the apparent lack of alternative studies, or why non neo liberal discourse has not been considered worthy of exploration during the last fifty years. This may be linked with the period of rapid growth there is little incentive to consider change, and where alternatives are proposed that question growth, the typical response is to dismiss them as marginal or to simply ignore them (Daly, 2007; Hall, 2005).

Transport and freedom are closely linked within this ideology. The restriction of mobility through incarceration emphasises its importance given to movement as freedom within society. The freedom to move or be transported through the world and to have access to goods from other places is seen as a fundamental human right. Lawson questions the way economic methods interplay with social structure and rules when he questions the foundations of neo classical economic theory through his interest in social ontology. He defines this ontology as the "enquiry into the nature of being, of what exists, including the nature of the objects of study" and applies this to the study of society (Lawson, 1994, p. 257). Lawson's enquiry severely questions the relevance of formalistic economic models of social structure.

The literature places little importance on concerns about how transport supports or destroys non-market goods and services supplied to society and neo-classical economic thinking directly influenced transport geography study during the 1970's. As cheap fossil fuels reduced the significance of distance and energy factors of production, neoclassical economic ideology increased its influence over all transport related decisions. The view that transport, and all other social endeavours is subordinate to a view championed by organisations such as the New Zealand Initiative⁵, who promote the position of individual choice and the sovereignty of the consumer that implies transport is there to support an inalienable right to consume (Jeram, 2016).

⁵ The New Zealand Initiative describe themselves as an 'independent public policy think tank supported by chief executives of major New Zealand businesses.

Current socio-technical regimes that are reliant on goods transport define progress in terms of economic growth, increased efficiency of the transport function and by default accelerate the rate of resource depletion without a particularly clear social sense of the value or cost of consumption. The development of more expansive goods transport systems is rhetorically constructed as 'progress' and 'moving forward' are considered 'good' is problematic in a world with constrained energy supply and is symptomatic of the ideology that has created the current ontology of transport where it is primarily considered as a derived demand. As Lotka (1989) said, such rhetorical statements repeated often become a 'melodious phrase and soothing rhythm' that 'sing to sleep our curiosity' (1989, p. 545). This becomes problematic because 'when curiosity sleeps, science stagnates' (1989, P.545). What I find in the literature is just that; a lack of curiosity about transport and the sciences of living systems.

The reasons why this has not been addressed is that the current suppositions of which Dryzek for example is very critical, (Dryzek, 1987; 2005) entail a commitment to very different ontology. An understanding of what there is in the world, as understood through the lens of Neo Darwinian evolution, relies heavily on non-thermodynamic information in the form of gene frequency, and an assumed but unexplained struggle for existence where random genetic changes lead to structure and form. Within this understanding of evolution selection relies on chance more than physical forces that act on materials.

The lack of the identification of mechanisms that explain relationships between order and disorder mean that the social sciences have generally failed to ground research in an ontological world where everyone and thing of interest is 'in the same boat' as put by Quine in his systematic attempt to understand science from within science itself (Quine, 1960) . Harris' focus on cultural materialism begins to do this through recognising the presence of natural forces and material substance interactions within human culture, and his acceptance of Maxwell's (2009) suggestion that an explicit aims-oriented empiricism could provide useful methodology in addressing what form scientific progress should take in this area. Dryzek's (1987) frustration with the way collective social choice mechanisms act on ecological issues in particular can be explained in part by mainstream philosophical thinking focussing on other than material processes in the world and the implications of scientific discoveries on order and meaning. There has been a fifty-year side track away from addressing material activity of the world down the path of a philosophy with a focus on a semantic understanding of the world. In contrast to this, Neo-materialist thinking and the pursuit of naturalised transport ontology offers a new epistemic approach where active matter offers

explanations of structure and development via gradients of intensity that integrates the ideas of Dryzek and Harris with a Darwinian understanding of selection processes within existing populations.

Transport's contribution made possible via an oil-based movement enabled newly found geographic freedom allows the exploitation of the ideas of other thinkers from Cooley's time. The economic behaviour of market towns as described by Adam Smith has also expanded to describe a global village where 'the hand' reaches across borders, into political pockets and thumbs its nose at state sovereignty. Transportation provides critical functionality in the two hundred years of post-renaissance science and ideology, where human invention and innovation found ways to master time and distance constraints of the physical world. Ways to ground the freedom of this new thinking (and exploitation) came from Darwin, where liberal interpretations of the survival of the fittest are justified in the predation of resources and hinterland expansion made possible by the modern dray. The behaviour of the individual as decision maker derived from the conduct of atoms in a jar justified a whole economic theory of freedom of choice. For society, the discovery of oil-enabling modern transport is exploited through a whole new framework available to science, ideology, and energy technology.

There is every chance that unknown-unknown technical solutions and innovations will produce solutions to problems and improvements to energy use and efficiency. Rising energy prices will produce the immediate effect of using less energy. Rubin (2009) sees this happening through the 'low hanging fruit' of air travel, suburban sprawl, SUV's, and frozen lamb chops from New Zealand'. Transport features in all his examples. Cavana et al. attributes the demand for transport as the 'imperfect match between the distribution and production and consumption activities' (Cavana, Harrison, Heffernan, & Kissling, 1998). A constrained system still strives for order and complexity, which means that the end of cheap oil will not see history run in reverse (Rubin, 2009). A more likely scenario is one where there is a cannibalising of existing structure to maintain the most essential structures and where the diameter of the circle of the centre of activity shrinks.

The descriptions and activities of transport are interconnected with metaphors around social process that are considered progressive and good. Hagen uses the metaphor of oil being the haemoglobin of global trade and commerce (Martenson, 2011) and it is sometimes referred to as the economic bedrock of our hydrocarbon civilisation. It is closely linked with notions of progress as defined by a movement towards a goal, or higher standard, and toward a greater state of civilisation, as development towards a complete or more modern condition' (Oxford, 2000). Progress thus includes the concept of movement forward or onwards, as a motion towards something better. Where movement towards an unsubstantiated 'higher standard', or towards a

better state of civilisation, then calling such action 'progress' is a powerful conception, because, the metaphor of 'moving forward' and 'towards' something is accepted without much consideration as 'good'. Through the power of metaphor, progress is made tangible as transport, making the movement of goods by definition a desirable and a positive thing for a community.

The narrative of progress producing a good result is one of the simple narratives constantly reinforced, where the journey is metaphorically described as *upward*, and so continuing *onward* as has been the case over the last 30 years will produce a good result. When needed, marvellous new technologies will just 'pop up'. There is a belief that 'progress' is a law of the universe, meaning no going back and no decline.

Making progress where progress is good suggests that what is replaced is not progress and so is not so good anymore (Lakoff & Johnson, 1980). Political and economic choices may not lead to progress and may result in a less prosperous situation or simply a dead end and require society to back out of the one-way street and try another route. Ideology and social myopia (Offer, 2007) can deflect 'progress' to other aims and fail to respond to known or knowable risk. Progress is a central metaphor within current society (McGlone, 2006), however revisiting previous developments, not currently couched as progress may offer better paths to travel and it is not a failure of progress where there is reason to question the direction of current 'progress'.

There is however significant developments being worked on in Switzerland and Denmark that mean progress by way of 'drastic reductions in energy consumption' in response to population increase, and growing demand (Morrow & Smith-Morrow, 2008). Studies of this nature take make the point that 'putting off the change will merely drive us toward it' (Kolbert, 2008). A significant co-result of initiatives to reduce energy use is that it always reduces the amount of transportation.

2.5 Research gaps in the literature

The major themes in transport research and policy in New Zealand are centred on how the provision of transport infrastructure and increase in capacity to move freight efficiently can encourage and drive economic development. In government policy we find aspirational themes of transport and sustainability have been replaced by concrete improvements to transport infrastructure and development have become the focus of transport research within New Zealand over the last decade. There appears to be substantially less consideration in 2016 than there was in 2002 of the sustainable aspect of transport in New Zealand, with little apparent strategy and policy appetite for other initiatives apart from those that are consistent with considering transport as an inconvenient cost to other processes albeit one that, if minimised, stimulates economic

development. The mantra of 'derived demand' remains an unquestioned tenet in political debate and this may be because 'the challengers of the conventional wisdom have not mastered their intricacies' (Galbraith, 1958, p. 9) how to do that is not clear where there is no clear reason to change 'business as usual'. The literature on transport shows little appetite to challenge the current understanding of transport theory. There seem to be no alternative transport option being considered other than making what exists go faster and be more efficient.

Another factor that keeps transport on the fringes of research is suggested by Hall and Klitgaard, (2006) who say that a question rarely asked in economics is the relationship between energy and any economic activity. The root cause of this may be that orthodox economic theory does not predicate economic growth on energy flow and this is consistent with that view I have found this is not being addressed in research in New Zealand, even though increases in economic activity come with commensurate increases in the use of energy. What is shown is that the NZ Government does consider internationally imposed emissions levels to be a factor in future transport decisions where noncompliance would be a form of a threat to New Zealand as an exporting nation. The lack of recognition that the motive power that moves goods is almost fully dependent upon high quality energy is a problem that is largely and often wilfully ignored. The result is that transportation has been largely dematerialised in a geographic and economic sense (Rodrigue, Comtis, & Slack, 2006) and its ability to influence social structure is not deeply questioned. The current situation means there is little urgency to question or address theoretical perspectives of the interdisciplinary or macro systems impacts or long-term material nature and dependence on the finite stock of fuel that currently powers virtually all freight movement.

Transport research remains dominated by economic methodology and formalistic mathematical models steeped in a language that suggest a strong influence from neoliberal ideology and especially the tools of monetary cost benefit analysis that have become influential in how choices are evaluated when making make policy decisions that affect the general public. Neoliberalism ideological thinking is apparent in much of the last 50 years of government policy and strategy in defining the government's role as letting the markets make all decisions about economic development, and port infrastructure in particular. This seems to be at odds with the operation of actual economies in which transport functions are concatenations of biophysical and social activities and as physically based activity they always include materials and energy. However, these considerations take second place to models borrowed from physics and used as the conceptual base for definitions and analyses of economic systems. The clearest example of this is the early 20th century omission of land and energy from neoclassical production functions. The result is a

subjective utility function ignoring material and energy as measurable physical inputs and outputs. The change favours market based human preferences as superior measures of production, so the biophysical basis was reduced in economic importance in what is considered the 'real' economy.

An extreme expression of this is the view that the axioms of economic social science is at odds with and misunderstands the nature of science, social science and the nature of the economy itself. (Beinhocker, 2013). The frustration that this causes is apparent in the large body of literature that is critical of the current economic paradigm and as a consequence there is a growing interest and an ontological revisiting of what it is that grounds economic dogma. A growth of internet searches for ontology and economics (Fulbrook, 2009) shows this concern as the potential for change is beginning to be explored (Lawson, 2003, 2012). However, it remains the case that Neoliberalist thinking supports and endorses the current limited methodological scope of freight transport as being something best left to and understood by engineers and economists.

It is therefore not surprising that most transport research is in support of increased GDP goals and industrial productivity, and with infrastructure development such as the building of stronger bridges and more motorway lanes. Government transport research objectives can be seen to filter out topics other than those connected with this narrow economic definition of freight transport. Again, this reflects that little consideration or importance is given to an overall theory covering the physical, energy and social aspects of transport. This also prevents a satisfactorily inclusive explanation of the wider conceptions of goods transport 'within the world'. Transport becomes a descriptor within, but not the subject, aim or objective of that research. Each discipline that must deal with aspects of the movement of goods relies as a starting point on preconditions suited to or axiomatic to that discipline.

There is a lack of historical depth in the current theories supporting freight transport theory. For the last thirty years, the transport function has been cast almost exclusively in economic terms as a derived demand. In many ways this is understandable as modern freight transport has only seen year on year exponential growth and this does not challenge the theories or suppositions that support transport extension and expansion. There is also a lack of behavioural science research to complement early models of freight transport driven by technological advance, and the economic model of the past forty years (Hibbs, 2000). A unified theory could integrate transport and communication elements with engineering, economic and behaviour science. All five elements are currently disjointed with respect to transport theory (Hibbs, 2000; Tiffin & Kissling, 2007).

Knowledge about transport systems lacks an adequate grounding or basis to address social implications within the power of changes to freight systems. There is no interdisciplinary grounding theoretical basis that satisfactorily explains in other than economic terms why freight moves, and what significance should be placed upon moving freight from place to place. There are no theoretical or objective limiters on when or where transport should happen.

The type of topics funded as freight transport research commissioned by governmental agencies are highly influenced by the economic ideology of the time and aimed at the execution of socio-political development that do not appear to take into consideration energy, social structure, and distance. To date, transport study offers solutions reducible to metrics, which are highly assumption bound. The transport resource has no informed quantum or inherent boundaries of when where and how much of it to use within the overall resource available to the social system it serves. What is lacking is a clearly explained theoretical transportation perspective instead to replace or at least to compare with the way transport is explained by the range of disciplines with an interest in freight transport.

The reduction of government interest in directing future transport system development leads to what Hesse calls a lack of entanglement with issues of space and time (Hesse & Rodrigue, 2006). This takes away any urgency to address the lack of unity between economic, ecological, and geographical concepts as they apply to a philosophy of freight transport. Transport policy, focussing on safety and efficiency misses the big issues of freight systems design in an energy constrained world. However, the gaps are only gaps if one believes that there is no alternative to present neoliberal ideology. Some research attempts to patch and compensate for the gaps in the knowledge, but little is being done to consider freight transport system structures in timeframes compatible with the life of the transport assets, or in an energy constrained world. There is evidence of high level government concern on the reliance on one type of fuel to move goods to overseas markets. There seems to be moot acceptance of Reagan's view that human intelligence, imagination, and wonder, will maintain growth. This is in abject contrast to the concerns that M King Hubbert, the originator of the concept of peak oil has when he said:

My analyses are based upon the simple fundamental geologic fact that initially there was only a fixed and finite amount of oil in the ground, and that, as exploitation proceeds, the amount of oil remaining diminishes monotonically

((Hubbert, 1982)

Transport theory in non-human driven processes is barely addressed at all in the literature. There is a need to understand and illuminate what the physical processes are that are represented by work and feedback in the 'back box' parts of transport evolutionary processes. These are processes that have known inputs and outputs but where the mechanism of the creation of a new totality is taken for granted and not explained. To understand transport processes requires this clarity and a language that describes how this physical information and material structure comes about. A metaphysics that explains intelligence in material systems would help to access further new knowledge.

While there is some wider discussion about goods movement I found limited evidence of transport being theorised in a wider context than as a derived demand or factor in production systems. The nature of research is questioned by some researchers, and this is evidenced by the staff of the Transport Studies Unit at University of Oxford who want to encourage an integrative and wider aspects of changes transport makes to the economy, environment, social equity and wellbeing (*Handbook of transport and development*, 2015). What I did not find in their work, or the literature reported on by Transport Research was research that extended outside of systems thought up by humans, or even any questioning about what could be learned from non-human social transport systems. In fact, transportation science research is trending in the other direction, with an almost total focus on machine powered transport.

A reason for this may be that during a time of consistent growth and abundant hydrocarbon energy supply that the transportation function hardly needs to be theorised at all. Here, linear modelling satisfies or satisfices. Research focusses on transport econometrics with a reliance on statistical analysis and incremental improvements to efficiency through the use of transport and communication technology. Applied transport research mainly considers transport within a predictable environment relying on past trends of constant and positive growth. Forecasts based on previous patterns have a reasonable degree of accuracy in such an environment but are exposed to the danger of being fooled by the logic of science (Taleb, 2008). Also, the selectivity of research and factors used for statistical analysis can be used to support ideological and political agendas. The research funding filtering process means that non-applied research, or research not in line with current thinking is subject to passive alienation through not being funded. The focus on applied transport research has suppressed research into other than for efficiency, safety, and cost.

2.6 Review and summary

In this chapter I have reviewed transport policy and research issues in New Zealand that have relevance to goods transport. I also provided some background about the ideology and aims of neo liberalism as the language used in policy and strategy documents suggest that neoliberal thinking influences transport decisions and policy. In reviewing international literature, I find that the same themes and focus are found but there is more research focussed on a more general relationship between transport and society.

The way goods are moved are theorised as a strategic tool of commerce and a factor in determining whether investment is made in warehousing or fast-moving consumer goods supply chains. Supply chains can start, and end anywhere and so challenge the inflexibility of 'place' as a spatial geographic concept. This type of thinking expands the role of transport in the networks of goods movements.

Research covering the movement of goods continues to consider transport predominantly through an economic lens. Any variation or suggested alternative is still in an embryonic form with only aspirational hopes that the future of global production and consumption must improve environmental and social sustainability. The main themes of research centre around short-term gains achieved by increased efficiency, reduced cost, and extensive accessibility of transport services. In contrast to current research the research focussed on energy efficiency in the 1970's considered transport in wider terms of natural patterns of energy flow and that contemplate the critical role of oil reserve depletion. The current discourse masks scarcity as a real issue and downplays limitations to growth and by implication assumes ongoing resources availability and ongoing growth.

Transport modelling using neo classically influenced geographical tools tends to create models with assumptions modified to fit with the apparent cause and effect, or 'immediate' cause. As Rodrigue cautions, a focus on modelling favours a disconnection between theoretical and empirical approaches (Rodrigue, 2013). Highly self-serving concepts such as innovation and entrepreneurship, or technological possibilities expressed in economic models as a production function (Solow, 1956) enable theorising about growth and development to be fetishized. However, such explanations fall short of informing a deeper understanding of transport energy, geography, and evolution. There is little questioning in the literature about the value of what is being transported or the value of limiting transport demand caused by unfettered social demand for goods. As an economic tool

expanding freight transport capacity supports competitive advantage, resource exploitation and the geopolitics of oil use.

The overall effect of this means there is little appetite for an alternative theory of transport, especially one that challenges the hegemony of world power through hydrocarbon dominated geopolitics and the ideology supporting neo liberal capitalism. Consequently, there has been no urgency to define the interdisciplinary nature of freight transport as there has been no compelling reason to do so during the past thirty years. Transport development used as a tool to extend the 'reach of human actions' presented through globalisation (Bossel, 1998), has equally been enabled by developments in transport communication as described by NETS theory (Tiffin & Kissling, 2007). Their research and explanatory framework for freight logistics as an integrated transport science in the study of globalisation pioneers the discussion about the contexts within which transport happens. The discovery and exploitation of oil in the early 20th century found that rock oil (petroleum) greatly benefited trade and war by increasing the speed and reach of influence that Cooley (1894) theorised about. Modern transport is now shaped and defined through the development of the internal combustion engine and its application to land water and air transport. Previously problematical geographical limitations of distance, communication, time, and spoilage obstacles to accumulation, were overcome by cheap and robust transport capacity. For the last two hundred years our economy has enjoyed the benefits of transport and a trend towards apparent free transport – with some researchers saying that now that is what it virtually is (Glaeser & Kohlhase, 2003), as the economic world shrinks in a way that Cooley could not have ever thought possible in his time. Theorising about how transport operates is very limited within the existing policy views of the problem, with particular interest being in matters of efficiency, and the role of transport in international trade under the headline of globalisation. There is a lack of variety in and critical appraisal of the methods used in freight systems theorising and analysis. The assumptions made are not explicit, or consistent across domains of both natural science and social science for which freight transport is a functional component within the complex systems served. The literature generally heralds no particular development of transport and systems other than more of the same, with a reliance on technology to streamline previously manual tasks. There is a lack of awareness of geographic issues on transport and an over reliance on economic freedom of choice in its assumptions of how social good is achieved. There is a disconnect between freight transport development and energy supply and the focus on increasing infrastructure to support the free flow of private and business vehicles.

The gaps in the research result in a lack of clear information about what alternatives to 'business as usual' could even look like. Alternatives are fragmented and localised and have no clearly articulated reasons not to continue to expand GDP. However, the veracity of earlier models such as those done by H.T Odum and the Club of Rome that situate transport and economic activity in a constrained world are still useful for guiding current research and should not be discarded just because they do not look attractive in times of exponential growth. Certain sea changes, such as the current issue of rising sea levels and hottest years on record, may well create a revitalised interest. What has remained constant are the geographical, location and hierarchical elements that approximate flows, nodes and spatial structures in natural systems and so remain as the building blocks for alternative development and may benefit by being situated within a more comprehensive framework.

There is no specific research addressing freight transport in terms of entropy, power, and hierarchy to discover whether freight transport in its broadest sense operates as a universal enabler of living systems. Modern economics has limited understanding transport as an evolutionary factor-creating process, considering it instead as a tool of competition subordinate to innovation as a tool of progress. As an interdisciplinary field of study, the ubiquitous act of moving matter has lost or has never had recognition other than for what it achieves. The upshot of this is that there is no satisfactory home for transport within our understanding of the workings of nature, the economy and energy flows.

This leads me to question the fundamental (ontological) understanding and presuppositions of how nature works and whether the inclusion of transport in some meaningful way may feed back into evolutionary, economic, and thermodynamic research an additional dimension to the governance of social systems that have transport elements. Would a more thermodynamic and materialist centric view - in some guise - lead to a better home for transport?

Chapter 3

Energy, flow, structures, and transportation

Where there is competition between systems, those systems that survive are those that develop the largest energy inflows and use them most effectively to feedback and bring in more energy

(Howard Thomas Odum, 2007)

This chapter explores how energy flows through or is transported within and between living systems and entities. It starts with an exploration of thermodynamic flow properties and the relationship with natural growth that includes a consequential development of complexity. I explore that thermodynamic gradients play in transport flows and how the characteristics of these gradients, or intensive differences are described through the exploration of various heat machines, such as hurricanes, thermal currents, and geothermal events. I then focus on the metaphysics of ordered systems that arise in disordered energy flows by investigating possible reasons why systems appear to self-select for structure in a manner that maximises energy flows. I then consider the implications for transport theory of Odum's claim that the principles of hierarchical energy flows found within living systems also apply at the scale of material and economic flows found in human social systems. A discussion follows that considers the attributes of transport in systems that includes the notion that there is a thermodynamically active component that selects and develops pathways to create complexity in living systems. I find this alters my perception of what transport is in living systems and this sets the direction for further searching and probing questions about what can be understood within active natural systems about energy flows in and between entities that are enabled by transport.

3.1 The history of thermodynamic understanding

The study of the nature of thermodynamic flow began not through arguments of logical necessity or as an explication of a theory, but by observation and repeated trials mainly carried out by practical engineers in their workshops. In Chapter 1 I gave a general definition of transport as carrying physical mass, or matter through time and space both within a system itself or across boundaries, or through portals to other systems. A feature of goods movement that I identified in Chapter 2 was how a flow within a network that uses high quality energy and is guided by communication processes, suggesting there is a close relationship between transport and communication processes

in the link between matter and the creation of order. The first Law of Thermodynamics states that energy cannot be created or destroyed, and that the total energy within an isolated system remains unchanged. However, within an isolated system the amount of free energy may change. The Second Law of Thermodynamics states that if there are any chemical or physical processes underway, then the overall quality of the energy in the system will degrade. As Carnot discovered from his experiments with steam engines, it is not possible to convert heat entirely into work (Schneider & Kay, 1994, p. 27) Carnot's formal statement of the second law reflects this:

'It is impossible for any system to undergo a process in which it absorbs heat from a reservoir at a single temperature and converts it completely into mechanical work, while ending in the same state at which it began. The second law notes that work may be dissipated into heat, whereas heat may not be converted entirely into work, thus proving the existence of irreversibility in nature'

(1994, p. 27)

Carnot identifies that work requires a difference or gradient, but he found through experimentation that not all of the difference can be converted into mechanical work. He also identified that there is a directional flow when energy is used to drive a process where that which changes cannot be reversed. This means that order creation depends on heat loss and happens with a lawlike directionality to which the degraded heat seems to be attracted.

In the late 19th century serious interest in the mechanics of energy flow developed in communities of scientists and engineers and was given the name 'thermodynamics', a compound word that expressed ideas of heat and force. The consistency of the observed phenomena of thermodynamic movement that always acted in the same manner led to the description of the phenomena gaining the status of the Second Law of Thermodynamics. Thompson and Clausius are jointly acknowledged as formulating the law which describes a directionality in heat flow where heat cannot itself pass from a colder body to a hotter body. It followed from Carnot's observation that the energy that drives a steam engine is not actually used up, but always moves from a warm body to a cold body where it still exists but in a dissipated form. Thompson and Clausius developed Carnot's conception of what the maximum efficiency of heat engines could be and confirmed that the conduction of heat between bodies of different temperatures appeared both wasteful and irreversible.

Prigogine spurred the current and ongoing debate that had begun in the early twentieth century by suggesting that processes resulting in low entropy showed tendencies and capacities that were dynamical in nature and not fully conceptualised within a purely statistical approach to describing

matter only in terms of its downward path to randomness. He raised questions about the application of statistical mechanics as a practitioner within a research paradigm where a statistical view of the mechanics of the world strongly prevailed and the time reversibility of particle movement. Within this community of scientists, he popularised discussions about how processes that led to the cancelling of differences through developing Bertalanffy's (1969) concepts of entropy as a dynamic process within his general systems theory and exploring how systems far from equilibrium could be better understood. Within this field Because he worked and developed a different conception of entropy within the orthodox views and was able to articulate how entropy accounted from times arrow and irreversible flows he successfully opened up a wider discussion of what entropy means and does within thermodynamic systems. His success in questioning how entropy is theorised and pioneering the new field of interest in far from equilibrium systems and the possibility that order emerges out of chaos. His contribution is recognised in a Nobel Prize for chemistry awarded in 1977.

The apparent directionality and movement that these pioneering thermodynamisists found provided a science-based restatement of Aristotle's idea of cause and the essence, or the quality of a thing 'that out of which a thing comes to be and which persists' (Bunge, 1979). The metaphysics of essences and forms, and the qualities of a thing become central to my argument about material properties from Chapter 5 onwards. The low entropy state or end point attractor alluded to here can also be restated by saying that regardless of the order that constraints are removed from an isolated system it will always reach a unique state of equilibrium (Hatsopoulos and Keenan, 1965 in Schneider & Kay, 1994). To get a clear understanding of thermodynamics is an essential first step towards formulating a clearer description of how the things of the world interact and how directionality and energy transportation or 'force' are part of these interactions. This is important if thermodynamics and motion between different types and scales of matter can result in complex new whole entities with their own properties. This problem is addressed by life sciences generally, however is it not usually addressed from the point of view that places much importance on energy flow and transport. One discipline where energy and transport are central to the understanding of energy flow is the study of ecological systems. HT Odum pioneered this field with his pond studies in the mid 1950's and the use of scientific method to map energy flows in ecosystems.

3.2 Odum and energy transformation

During his research career HT Odum found that at a time of accelerating growth and an apparently unlimited flow of high quality energy there remained an ignorance about the importance or nature of energy flow and its natural use within systems (Howard Thomas Odum & Odum, 2001, p. 57).

Knowledge of how these relationships affected social systems expanded during the 1970's driven a focus on the effects of limited energy flow, but interest in this lost momentum when oil became cheap again. Odum's work develops a quantitative and qualitative ecological systems understanding from empirical observation. Odum continued with his work and showed that systems maximise energy input to create more order and maintain growth in their structure by using that structure to further increase energy input. The self-reinforcing feedback nature of this process became a central theme of his research into the relationship between environment, power and society (Howard Thomas Odum, 1971). He described how energy for complex systems comes from the surrounding environment and found that the more complexity and order there is, the further the reach of the system becomes to draw in and accumulate the available energy. Here we see how integral transport systems are in the accumulation of power by controlling materials movements from the hinterland or local environment and concentrating that power in identifiable centres. The physical activity is linked with the influence exerted by feedback systems within high complexity and high-quality energy flows.

Odum observed that during times of rapid growth the emphasis within human systems is on competition that results in large differences in economic and energetic welfare development. During this type of growth energy efficiency is not maximised in natural systems, whereas spatial coverage and maximising energy throughput are. A similar case can be made for growth behaviours in human systems where access to the high-quality energy embedded in fossil fuels allows societies to expand rapidly their power inflows. With the survival premium being on rapid growth, it is inevitable that there will be waste and inefficiency. In the natural world it is weeds that first colonise and cover the energy receiving surfaces. The energy capturing efficiencies of plants labelled as weeds are wasteful, and their structures are not designed to, last-but they are effective at getting growth established. This colonising behaviour found in nature is called 'Grow or perish – which is the correct response when energy sources are not tapped' (Howard Thomas Odum, 1974). When a human economy is in a period of rapid and 'chaotic' growth it behaves in a similar way, with energy used in transportation focused on extending geographical coverage and not on efficiency of use. The economic aim is to characterise by a bid to colonise new markets and secure resource use, and it is under these conditions that cause large differences in economic and energetic welfare to develop. This happens in contrast to periods of stable growth or steady state growth that are characterised by regulated systems, and high division and diversity of labour, and uniform energy distribution and a focus on efficiency. Translating natural systems behaviour to social behaviours to questions about whether it is possible that energy flow characteristics are in some ways an active determinant of social structure, and if it is credible to accept that matter has an active in how

human behaviour is determined within social systems. This implication and more poignantly, the explications for transport in this question are addressed in Chapter 6. What Odum graphically shows

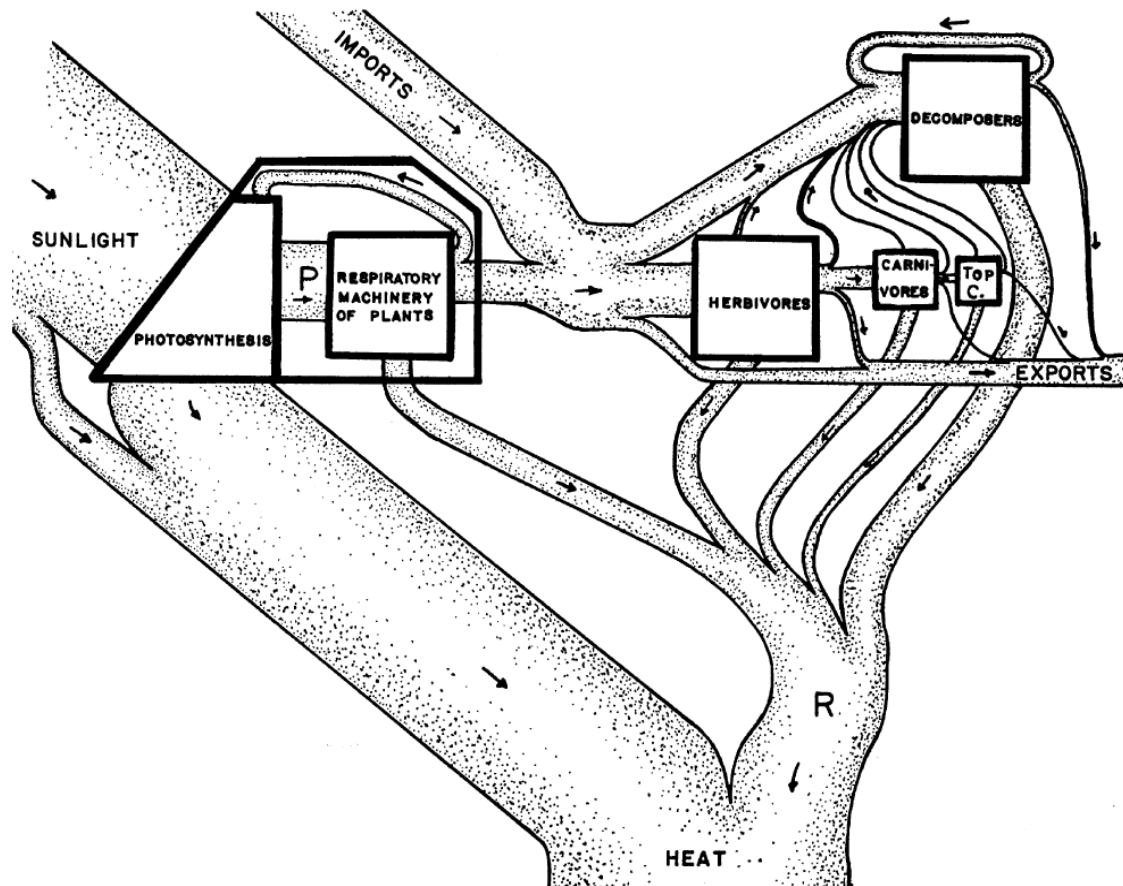


FIGURE 6 ENERGY FLOW AND NATURAL STRUCTURE

SOURCE: (ODUM, 1956)

in his work is that transformations of quantity and quality are clearly linked to energy flow. Figure 6 is an early diagram that visually encapsulates Odum's conception of the nature of energy flow for steady-state natural communities. Odum uses diagrams, or 'big pictures' to show a macro view of how this system operates because he felt that the information and complexity of the world call for a way to 'see' what constitutes the most effective human actions in a world that contains so many confusing clues that otherwise overwhelm both physically and psychologically. He shows here that a living system must have a fresh flow of energy flowing through all processes and that energy mostly degrades to heat as it flows through every stage of transformation within the open system. The production process moves from left to right. The letter 'P' located between 'photosynthesis' and 'respiratory machinery in plants' represents the gross primary production from energy flow in sunlight. Herbivores are the secondary production with continuing production through carnivores and top carnivores. The heat loss R near the bottom of the diagram is the total community respiration. In this diagram there are five trophic levels ordered and progressing from right to left in

the diagram to denote changes in energy quantity and quality. An important aspect of natural energy flows he shows here are flows to heat loss, and energy feedback loops in a system where some energy is converted to higher quality levels, and some energy being fed back. Odum (Howard Thomas Odum, 1956) found from his field studies that systems develop storages of high quality energy and those storages are then fed back as an energy source at a lower level to increase the efficiency of the inflow mechanisms. Each system also sets up exchanges for needed materials with more and less complex systems and so contributes to work at the next larger system scale and acts as on contributing systems.

To help elucidate the complexity of interaction Odum created a systems language, using a toolbox of symbols borrowed heavily from electrical circuitry diagrams into which he substituted the electrical componentry with his own systems language symbols as shown in Figure 7. His systems methodology has gone largely unnoticed since its creation in the early 1970's. Diagrams like Figure 6 provide an uncluttered macro view of energy flows through living systems, and account for the total inflows balanced against outflows and where every stage of the process results in heat loss. In taking this approach Odum's thesis is that 'complexity must be reduced to essentials if complexity is to be overcome as an impediment to understand and correct action, and this means modelling'⁶ (M.

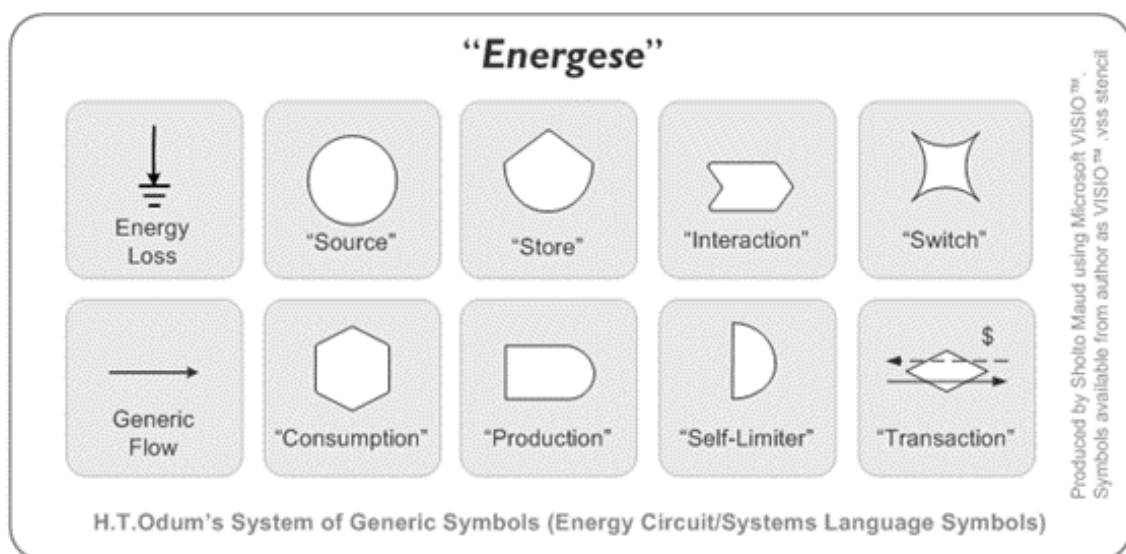


FIGURE 7 ODUM: SYSTEM OF GENERIC SYMBOLS

SOURCE: MAUD, S WIKI MEDIA

⁶ The development and the potential utility of models and modelling was an argument that had to be made in the 1960s in a number of disciplines, see for instance Chorley and Haggett 1967, and specifically in relation to ecological modelling and its analogies see Stoddart (1967) in that book.

T. Brown, 2004, p. 91). Odum called the models he developed macroscopic mini-models to suppress detail and capture the 'subjective qualitative essence of facts and figures' (2004, p91).

Odum reasoned that the use of macro diagrams that developed and quantified flows of energy of different qualities and at different scales might apply to more than ponds and forests and developed an argument that they applied equally as well to human economic and social systems. He found that flow in networks is not random movement, but movement as feedback that reinforces systems that efficiently transform the most energy into useful work. Where feedback action occurred they worked to capture more resources or to improve the efficient use of resources feeding into the process. Figure 8 shows how feedback processes are depicted using his symbolic language. It is a network of interactions and not an isolated activity as benefits also flow to surrounding systems (Howard Thomas Odum & Odum, 1976). He stated this as the power principle as 'during self-organisation, system designs develop and prevail that maximise power intake, energy transformation, and those uses that reinforce production and efficiency' (Howard Thomas Odum, 1995, p. 311).

Odum identified similarities in different systems and at different scales, and used the tools he had developed to model a range of systems' behaviour (Howard Thomas Odum, 1971, 1974). He found evidence that common designs following common principles exist in all thermodynamic systems and at all scales (Howard Thomas Odum, 1996b). That scale extends both upward and downward (see

Figure 10) from the ecological scale of human habitat and on that basis Odum predicted that chemical and biological entities would be found to have similar structure. Schneider and Kay also examined thermodynamic evolution of evolving systems and concluded that they comprise similar processes that are phenomenological manifestations of the

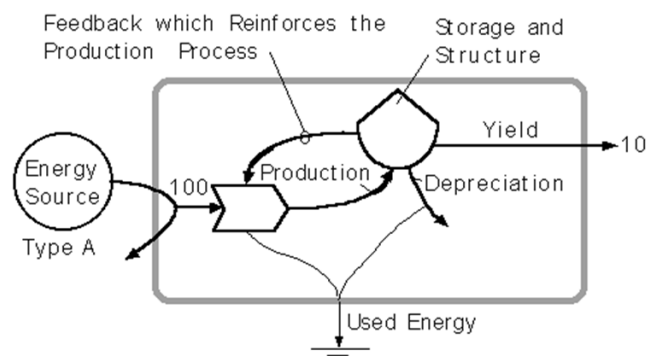


FIGURE 8 AUTOCATALYTIC PRODUCTION

SOURCE: (H T ODUM, 1994)

second law of thermodynamics (Schneider & Kay, 1994). Odum's (1971, p. 9) macro analysis of the scale of all things known places the human world at about the mid-point (See figure 10). This is very significant if it is accepted that patterns of transport within thermodynamic systems look much the same at different scales. However, even within the humanly accessible world there is so much detail, diversity, and activity that it can look like there is no organisation or principles at work. This has the effect of suppressing the search for macro and micro patterns in the behaviour of matter,

but is fast changing as information about activity at other scales is revealed using the tools of modern science

How physical mechanisms actually bring about a change in energy quality and material structure are the least explained part of Odum's work. Odum provided an extensive blueprint for the development of energy systems, but a Google search of research literature for his name and the term 'emergy', the term he used to denote the idea of embedded energy, show that he has remained outside the mainstream scope of enquiry for the ensuing fifty years.

Odum's cumulative 'emergy' approach to energy transformation needed a new way to measure levels of energy quality and so he settled on joules of sunlight as the common energy denominator for all energy flows. He called it emergy because 'energy in systems is converged while being transformed onto smaller but more valuable forms' (Howard Thomas Odum, 1987). A practical way that emergy analysis can be used is as an environmental accounting device that values the contribution of ecosystem goods and services expressed in one currency and this makes the comparison of different forms of energy flow meaningful. It is a more complex measure of energy quality than is used in life cycle analysis (LCA) (Reddy, Kurian, & Ardakanian, 2015), as that measure includes energy of production and manufacture only. A significant problem with emergy is that measurements are difficult to collect, and quantify, and so, as a concept, economists, physicists, and engineers have largely ignored it.

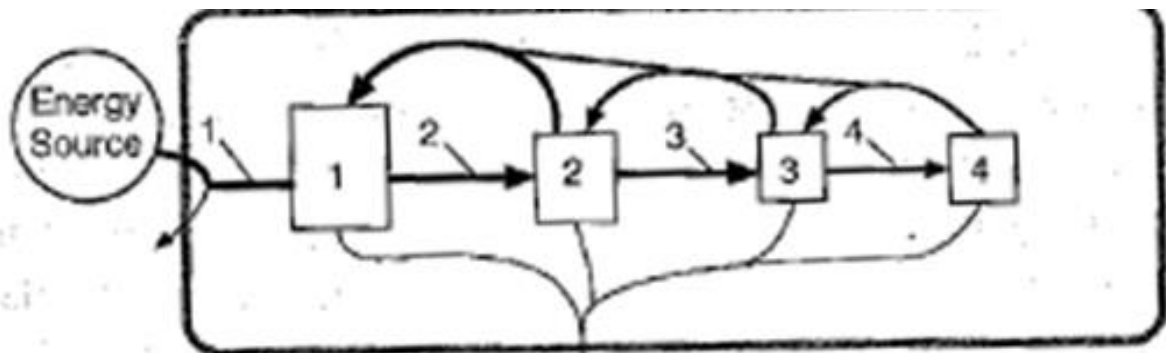


FIGURE 9 FEED FORWARD AND FEEDBACKS

SOURCE: ODUM, 2007. P77

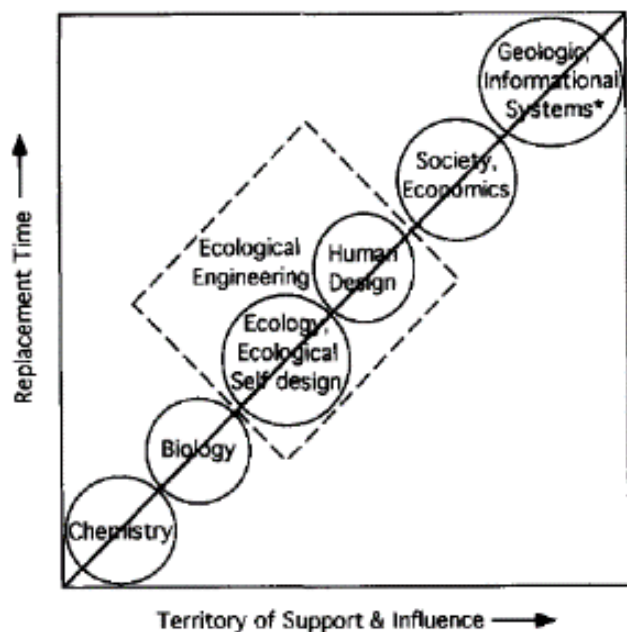
A feed forward process results in increased stores of higher quality energy, which in turn is influenced by a feedback process in a way that increases the performance of the system. Systems have a finite capacity to store high quality energy can only feed small amounts of energy forward. At times the amount available is large that the system cannot cope and so the system changes the way it operates, and energy is released out of the process. When it happens in natural systems - as a

consequence of the rapid release of waste energy – it happens as an intense discharge of natural high quality Energy (rain clouds, wind information), results in storm like events. Seasonal floods are an example of this, where the natural energy hierarchy may have been over stimulated or change phase, causing a frenzied event that impacts on a very large area. Odum sees such apparently destructive events as also having a feedback benefit on the system, in the form of the redistribution of minerals, silt and vitality to the lower quality energy fields it affects. A major flood is an example of infrequent, high pulse strength events typical of high transformity energy release. In considering the essential requirements for life, one of them is a pulsing⁷ The process of feed forward and feedback creates what Odum calls ‘maximum power’ which includes a process that selects pathways with the greatest energy flow into the system. This is achieved where well-developed natural systems select paths that extract maximum energy at each quality level, and so avoid ‘storm’ events and this means that the maximum work out of available energy is possible.

Another aspect of Odum’s work of importance to transport is that of scale. Much scientific research remains focussed on the reduction of that being studied and this approach is prevalent within the study of evolution and demonstrated by a

focus on the informational content of genes in the attempt to improve human life. Using these methods provides a partial or granular view rather than a holistic view. He said that fields of university study are at this level and would benefit by becoming interconnected and studied as a unified whole (Howard Thomas Odum, 1996a). Odum worked on the premise that to understand a system or systems at one level you must understand them at the next higher order.

Odum calls higher energy that is fed back ‘growth stimulating’, where the main sources that act on lower energy flows are sunlight, fuel reserves and natural and manmade structures (Figure 11). Transport and advertising in



*Global and regional systems based on widely shared genetic and cultural information

FIGURE 10 ODUM TIME AND TERRITORY WORLD SCALE

SOURCE: ODUM, HT 1996B, P8

⁷ The others are

this context are examples of the third type of higher level feedback. The feedback mechanisms can differ depending on intensity of energy flow. Flow processes change from linear at low energy influx to autocatalytic above a certain energy threshold. The way transport processes act here could be likened to a turbo charger on an engine where some of the high pressure, high quality, or intensive output is fed back as an input to increase the total power output for the whole system. An agricultural example of this same mechanism is the role oxen play in preparing paddy fields for rice where the advantage of higher quality animal energy input is realised early in the season where ploughing suppresses weed growth and so creates the advantage needed for rice plants to become the dominant crop. An understanding of the importance of the intensive effect of feedback systems, and by identifying the points where phase change occurs offers insight that can inform methods of building resilience in systems. The movement of mass play a big part in this approach to system health.

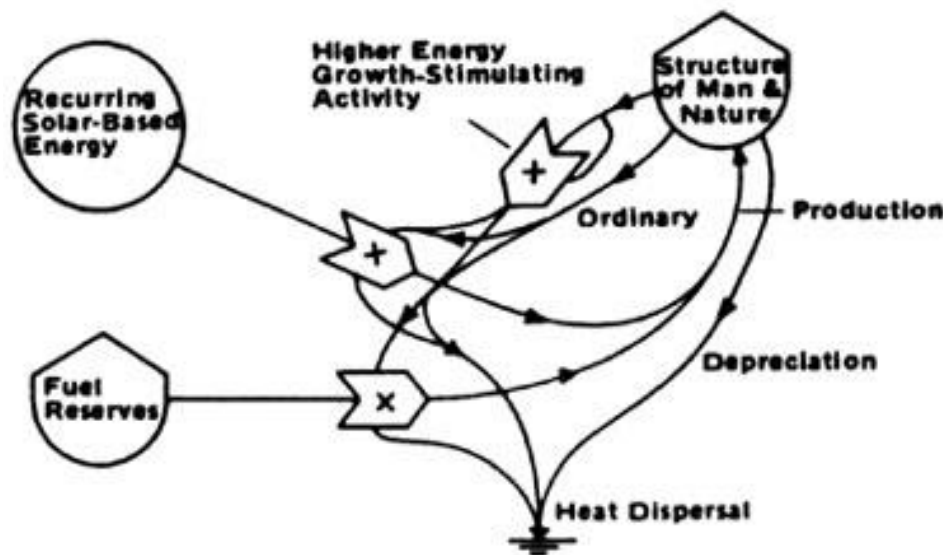


FIGURE 11 FEEDBACK MECHANISM

SOURCE: (HOWARD THOMAS ODUM, 1973, P. 221)

Odum identified process that lead to energy concentration and a gain in power throughout the entire ecological system where systems with access to the greatest energy flows build the strongest and most complex structures. Odum transposed this idea onto similar energy flows through social systems said that, are characterised by work, trade and money flow (Howard Thomas Odum, 1973). What is significant here is the unilateral inclusion of natural and human processes within his macro model of the selection, flow processes and the concentration of power.

By applying these order production and power production findings to economic systems it follows that the role of transport processes maybe similarly translated. Transport processes are identifiable in energy flow systems that feed forward and feed back to maximise the power of the system, especially where part of that power is geographical reach. Powerful systems have greater physical reach as transport function brings energy bearing material from distant sources towards town and city centres. While transport is an energy intensive and therefore costly 'economic pump' it plays an important role in growth priming activities. When energy supply is unlimited transport acting as an energy pump increases total system power, making it a very influential tool of economic management. Odum's identification that complex systems feedback controlling energy to less complex subsystems as a governance mechanism. Sometimes the feedback is an accelerator of process and sometimes it is a limiter. It follows that the introduction of high quality stored energy into a stable system, accelerated by transport feedback processes, can cause disruption of an otherwise well organised steady state system. While Odum does not advocate limiting energy intake, as that would be contrary to his maximum power principle, he does advocate the use of pricing and resource accessibility as a way to use power intake to develop low depreciating assets, and feedbacks that get the most power from the system. Odum advocates for example limiting the engine power of private cars, the restoration of natural capital and associated environmental production, limiting population, income upper limits, and the decentralisation of organisational hierarchy. An extensive list of policies appropriate during growth, for sustaining climax, and for descent can be found in his work on adaptive policies for climax and decent (Howard Thomas Odum, 2007, pp. 388-391).

Odum raised awareness of the role that energy flow has in all ecosystems at a time when any consideration of energy flow was virtually absent from economic activity models even though Soddy had identified its importance to human systems many years before that (Daly, 2005; Soddy, 1912). What Odum said is that the laws of energetics that regulate the physical and chemical world are also the main controls over human survival and prosperity. His work suggested that in terms of survival anthropocentric and ecosystem activity have a common basis. This is a large deductive leap across many disciplines, and not one attempted up by other fields until the recent interest in new materialisms.

The factors that neo classical economists say create growth are interactions in the relationship between capital and labour, where system values can be quantified financially. Solow (1956) found this to be an incomplete model and that economies grew at three times the rate that his models predicted and so he added an exogenous factor into the equation responsible for the major

contribution to growth that neither Solow or Swan could explain and Ayres & Warr call 'technological progress' (Ayres & Warr, 2004b). Leuning, writing as an economist, defines it as the Total Factor Productivity (TFP) growth that measures the rise in output possible from a given level of inputs, caused by the introduction of new technology (Leuning, 2011) and so attributes factors of innovation and entrepreneurship as responsible for the otherwise unexplained growth. Ayres and Warr however show there is a close tie between energy resources available to an economy and economic growth and say that the energy relationship can explain the vast majority of economic growth for a range of countries including Britain and the United States of America between 1900 and 2000 (Ayres, 2008; Warr, Schandl, & Ayres, 2008).

The potential to engineer steam powered motivation from fossil fuels enabled the widespread development of mass transport as a technological outcome of managing the intensive gradient available through burning coal. For the two hundred years since the industrial or more specifically the energy revolution, the use of fossil fuel has been treated as an unlimited economic resource in growth models. The way waste flows of heat gases effects environments within economic systems operate are considered externalities which characterises energy use as an inert material resource controlled and the beck and call of technical prowess. What I have found is that the impact of energy flow actively shapes and defines process interactions common to all living systems.

Large amounts of energy flows through natural systems at times that cause energy short circuits to waste, instead of dissipation through usual channels. Where large pulses of energy cannot flow through a system at a processable rate the system changes state and energy are dissipated via phase change such as normal airflows becoming cyclones and a build-up of pressure in the earth's crust causing energy release as an earth quake. Odum considers the exploitation of hydrocarbon reserves in much the same way. He says that what is being experienced with the free flow release of hydrocarbons is an energetic short circuit enabled by the unleashing of millions of years of stored high quality energy at an order that has no historical parallel (Howard Thomas Odum, 1971). The example and impact of natural energy short circuits such as tornadoes pale in comparison to the release and burning of the high-quality hydrocarbon energy stock, suggesting that the hydrocarbon by-product release may trigger other phase transitions to other Earth systems. In considering Odum's study of energy flows, the release of stored hydrocarbon energy terms has caused a manmade 'pulse' event where humans and materials collectively alter the environment. There is therefore a similarity between ecological pulses events such as those that lead to a large increase in biomass production, to energy pulse events in other material processes on the earth. Human production processes that release CO₂ and other similar greenhouse gasses are only part of the total

energy picture. There is also the central role of energy flow in material systems leading to the development of complexity, and the identification of energy flow architecture within all technical processes. Linked to this is the feedback accelerating value of human built transport systems in intensifying the development of these technical processes. The burning of fuels to increase the quality of life is not new as I discuss in the next chapter and was perfected by entities at other scales billions of years ago.

Odum's work attempts to describe the workings of technical processes where higher quality energy is produced within entities where some is used to sustain the entity, while some flows forward to power more complex entities and some feeds back in support of a hierarchical structure that maximizes the input of power available to it. The result is that systems that capture the most energy and extract the maximum potential exhibit higher levels of complexity than those that do not. I take from his work that energy flows both forward and backward are enabled through a 'goods transport' function that is both hierarchical and networked in its control and action.

Energy flow, as argued in the next chapter is a pre-condition of living entities that persist at different trophic levels, and the maintenance of those persistent entities entails the physical movement across or between material things in time and space.

How and why this happens requires an explanation, and the way Odum and Swenson (1998) describe processes where materials act upon each other to bring about new entities and structures helps to develop an argument for this. Their work is based on presuppositions with wider implications than explanations of efficient cause or evolution as a strictly neo-Darwinian gene selection process. Odum and Swenson describe processes where matter is acted upon by energy flows that leads to small zones or centres of low entropy material that form in the presence of a large flow of high entropy dissipating energy.

Darwin didn't set out to explain how populations got there in the first place, but to show how those that bred most successfully had the best chance of survival. Contemporary Darwinism can confine evolutionary thinking to the consequences of natural selection. The gene-centric view found in neo-Darwinian Theory therefore currently dominates how evolutionary processes are studied and limits the dialogue to concepts like competition and selection as its central ideas. It places little evolutionary value on transport and assumes it away. The current informationally based approach differs from Darwin's original thinking where he sought a mechanical explanation for interaction leading to evolution, reasoning that such actions could lead to, or cause adaptation in an existing population (Hoelzer, Smith, & Pepper, 2006). The gene algorithm, an optimising function for

problems based on natural selection is an example of Darwinism being used as a metaphor in statistical analysis. Transport network planning also draws parallels between transport networks and evolution as these 'randomly change over time' and that 'fitter variations are likely to survive and propagate' (D. Levinson, 2005). Natural selection is entailed by a situation logic requiring that natural selection occurs in a striving to 'seize on every unoccupied or less occupied space in the economy of nature' (Darwin, 1937 quoted in; Swenson & Turvey, 1991), heritable variation, and resource constraint. What is assumed by evolution as natural selection is what it does not explain and that is the intentional, meaningful end directed striving for the seizing, occupying and variation driven behaviour. It may be better to consider evolution as an algorithmic searcher that when driven by gradients is very effective at finding and assembling new things.

3.3 Swenson, entropy, and structure

The relation of matter and energy flow identified by Odum is further developed in the work of Swenson et al (1997a; Swenson & Turvey, 1991) who argue that Cartesian Dualism continues to influence the whole of modern science and so maintains an inherent ontological precondition that the mind is separate from matter, the knower from the known, and the self from other, where biology is separate from physics and living things from their environment. What they say is that in effect Descartes' defines physics and psychology as mutually exclusive. The bifurcated world view thus accepted was further reinforced by Kant, who questioned Descartes' physical separation of the living mind from the dead physical world and claimed that biology and physics were incommensurate (Swenson, 1999). Boltzmann perpetuated the view that a physics-based account of the world effectively alienates the processes of the living world by reducing the second law of thermodynamics to a statistical law that quantifies disordered behaviour. Darwinian evolution is built upon the dualist view that psychology and biology in order production are separate to processes found in the physical environment (Swenson, 2010).

All living systems need a rich and steady supply of oxygen and that has sustained evolution and the persistence of all living thing and Swenson argues they are all internal productions of a larger planetary process, and the regular functions of a single biosphere. Ontologically this requires commitment to evolution as an ordering process at a planetary level. Darwinian theory fails in this as planetary systems cannot by definition be considered a unit of Darwinian evolution as there is no reproducing, or replicating populations of earth systems on which natural selection can act (Swenson & Turvey, 1991). Swenson instead argues that each system is an internal component process of the planetary system as a whole. Natural selection in this context is confined to a process reliant on internal variations within existing populations as it fails to explain how variations are firstly

possible within the system to which it is internal. The placing of natural selection as a special case of evolution reframes the way the whole evolutionary system can be understood. The narrow interpretation of natural selection is one favoured in Neo-liberal economics, with its emphasis on ‘the survival of the fittest’, and so narrows the scope of evolutionary theorising within social systems to one of efficiency and competition.

Swenson (2010) theorises that self-organising systems display evidence of an active selection mechanism that results in the self-organising of matter in the presence of energy flow. He says that flow structures are maintained ‘relationally with and through their environments and are described as autocatakinetic (ACK) structures’. The compound word ‘autocatakinetic’ is used by Swenson to describe an auto (self) and cata (down) and kinetic (of motion of material bodies and the forces and energy associated therewith) process within a systems (Swenson, 2010, p179) He defines ACK structures as:

An autocatakinetic system is a system that maintains its “self” as an entity constituted by, and empirically traceable to, a set of nonlinear (circularly causal) relations through the dissipation or breakdown of field (or environmental) potentials (or resources) in the continuous coordinated motion of its components.

(Swenson, 2010, p. 169)

The definition suggests that a form of natural or physical coordination is at work in the system. As Swenson’s ontology rejects any form of mind body dualism, then human intelligence itself must fall within the same lawfull, physical and epistemological world and also be subject to natural organising principles. The defining feature of ordered systems is that more entropy is created than if the system does not exhibit order (Swenson, 2000). This is shown in Figure 12, where it can be seen that at the point of transition from disorder to order, there is a discontinuous, or gateway to an increased rate of heat transport and so greater entropy production occurs than if there was no order in the system.

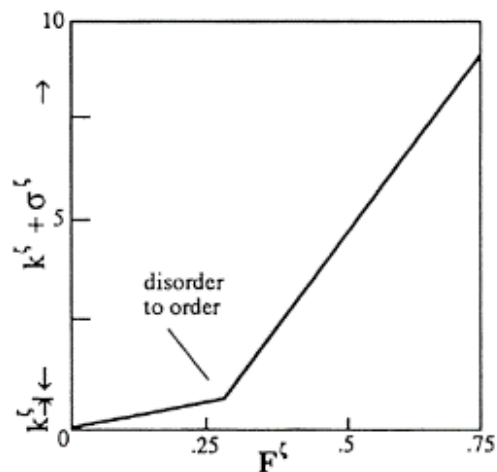


FIGURE 12 CHANGE IN ENTROPY PRODUCTION

SOURCE SWENSON AND TURVEY, 1991, PAGE 335

Swenson's contribution here is the identification of an over looked phenomenon, or little understood natural law – one that he calls the Law of Maximum Entropy Production (LMEP) for which he claims a nomological status along with other laws of thermodynamics. It Swenson's discovery that flows always allocate themselves to pathways that destroy potential the fastest remains overlooked as a principle of thermodynamics since first set out as the Law of Maximum Entropy Production (Gunter, 2014). It adds further insight to Odum's work that, systems select pathways for entropy flow that have both form and complexity that maximise entropy and that this inexorable process is a characteristic of all systems that are far from equilibrium and is the reason they persist. Put another way, the maximization of energy flow through an organization is made possible by efficient dissipative systems that follow natural law and always dissipates in the most efficient manner given the constraints of the system. It is observable law and so falsifiable and a commonly referred to proof is Bernard's experiment (Figure 13) first carried out in 1900 and repeatable today (Schneider & Kay, 1994). I reproduced this experiment in a household kitchen, using custard and so show the certainty and repeatability of the claimed lawful behaviour (see Figure 14 Organised custard). The experiment demonstrates how heat dissipates energy by changing state to maximise the production of entropy, and the organization is always the most efficient possible given the constraints. The repeatability is attributed to the autocatakinetic mechanism that strives to maximise entropy, regardless of how rough or uneven the starting conditions may be. The endpoint can be predicted as it is a lawful behaviour of heat dissipation. External constraints may act on a system, such as across a Bernard convection cell, they reproduce the same macroscopic behaviour every time and so knowledge of those constraints allows the prediction of the macroscopic result (Dewar, 2005).

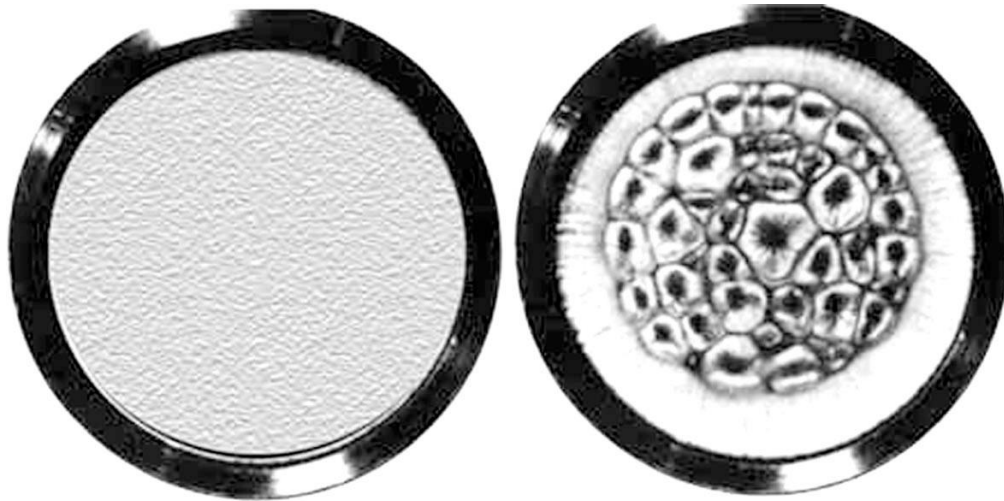


FIGURE 13 BERNARD CELLS

SOURCE: SWENSON & TURVEY 1991, p334

To make Custard:

Ingredients

- 2 tablespoons Edmonds custard powder
- 2 teaspoons sugar
- 2 cups milk

Preparation

Put custard powder and sugar into a bowl
 Mix to a smooth paste with 1/4 cup of the measured milk
 Pour remaining milk in a saucepan and gently heat until almost boiling.



FIGURE 14 ORGANISED CUSTARD

(SOURCE: AUTHORS OWN PHOTO)

Remove from heat and pour onto custard mixture in bowl; stir to combine

Pour custard into saucepan and cook, stirring constantly, until mixture boils and thickens

Makes 2 Cups.

Figure 14 is a photo taken looking down into a cooking pot containing custard that is cooling. The outline of hexagonal cells can be seen. This is the same pattern can be seen in mud cliffs at Gore Bay, North Canterbury (Figure 15), the Giants causeway in Ireland, lava flows at Halls Gap Victoria Australia, and the Moeraki boulders in North Otago, where boulders remain round, as they formed in isolation. The shapes share a common explanation: the hexagonal pattern, being crowded spheres that form in a way that optimises heat loss.

The architecture of Swenson's autocatakinetic system shown in



FIGURE 15 HEXAGONAL PATTERNS IN GORE BAY NZ AND HALLS GAP AUST.

Figure 16 is a

(SOURCE: AUTHORS OWN PHOTOS

diagram of a directional flow structure with temporal and spatial extension. Transportation processes enable the flow F_1 of low entropy energy E^1 through a work production stage that creates a quantity of lower entropy energy E^{11} . Transport processes then act back on the system by returning some of the high-quality flow (F_2) as an organised, energising input to the production process to act upon the potential in E^1 . The movement of E^1 energising input is end-directed by the pull of the used potential – the high entropy exhausted energy - into the surrounding environment E^{11} .

Swenson uses the structure of the autocatakinetic process to build an argument that 'order typically arises as soon as it gets a chance' (Swenson, 1997b) and expresses it as 'the urgency towards existence expressed in the fecundity principle'. He says that the world abounds with evidence of this, which is 'opposite on both counts with respect to the second law of thermodynamics as a law of disorder' (1998b, p172). If Swenson is right and this process is found extensively in the world, then this diagram could represent an abstract architecture of a type of universal developmental process. I explore this possibility in detail in chapter five.

In the following chapter I discuss developments since the turn of the century that provide human access the workings of molecular world and identify molecular level phenomena that support the physical and epistemic processes of the feedback mechanism Swenson calls 'autocatakinetic'. This

confirmation raises questions about the nature of law like behaviours other than those of efficient cause and whether causes and laws are intimately linked (Chalmers, 2010). Chalmers argues that the majority of philosophers seem reluctant to accept an ontology which ‘includes dispositions or powers as primitive’ (p219). Crotty, for example requires that empirically verifiable and law governed evidence that is able to be interpreted by ontology (Crotty, 1998).

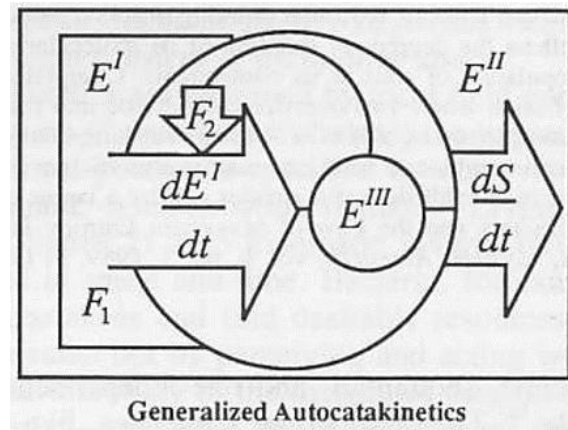


FIGURE 16 AUTOCATAKINETIC PROCESS

SOURCE: (SWENSON & TURVEY, 1991, P. 336)

Pursuing transport activity across many disciplines suggest this test is too narrow, and an ontology needs to provide an alternative to Crotty’s question about why it isn’t that the world is primarily subject to forces of ruination and decline. The general acceptance of a priori derived laws of how the world ought to behave may explain the lack of uptake to date of the ideas of Odum and Swenson and accounts for the surprise expressed by scientists who find epistemic and intelligent behaviours in non-human systems, as they have traditionally fallen outside what is allowed by an Enlightenment definition of cause and effect. Swenson’s proposed law of maximum entropy production identifies that in all cases energy flows always take the most direct path towards high entropy.

The nomological nature of this selective process meets the criteria of being observable, replicable, and measurable and could be called a common design mechanism. The repeatability of singular path choice mechanisms adds a consistency and direction to any flow caused by any energy gradient. Identifying nomologically consistent behaviour that directs processes of living, non-linear systems provides a wider basis for theorising transport systems behaviour. Common designs and principles found in transport rich energy flows further entwines transport processes with evolutionary processes.

3.4 Energy flow and transport processes

Views on entropy range from the very simple idea that ‘energy dissipates’ to concepts of entropy as a measure of how computer networks handle information. This situates entropy as a statistical state, where tendency of an inevitable randomness in the universe is measured. Boltzmann (Lebowitz, 1993, p. 316; Swenson, 2000) focuses on the statistical functions concerning ‘tendency’ to describe how randomness comes about and says that as a consequence, spontaneous order is

infinitely impossible. Since Boltzmann's reduction of entropy production to that of statistical tendency, a lot of debate has gone into what entropy actually is, and some conjecture about what it does. Clausius, writing at a time of burgeoning scientific enquiry in the 1860's, wrestled with how to define thermodynamic behaviour and is credited with saying that 'the energy of the world remains constant; the entropy of the world tends to a maximum'. Swenson is among those who disagree with a narrow definition of entropy as the statistical variation in a population. Boltzmann shows that in near equilibrium closed systems, particles *tend* to a maximum. What Swenson found when he read the original German was that Clausius actually said:

Die Entropie der Welt strebt einem Maximum zu

The word 'strebt' translates from the German as 'aims, seeks, strives, aspires' but not 'tends'. Swenson therefore argues for a fuller exploration of Clausius's originally intended meaning. The 'seeking, striving' or 'aspiring' allows Swenson to argue that order within an evolutionary process spontaneously occurs because the pull of entropy maximises energy flow in ordered systems. Structure then develops because ordered and more complex systems can produce entropy faster than disordered systems. This is subtly different to the view of Odum who attributed maximised power as the driver of structure.

That second law of thermodynamics is silent about the path or means for achieving change. Swenson (Swenson, 1997b, p. 13) says that dynamically ordered structures will select the best path from all possible structures in order to maximise entropy production in the fastest way possible. Swenson provides a clearer case for maximum entropy production being a nomological law than Odum's focus on maximum power aligned with Darwin's focus on competition and fecundity to explain why things evolve. It seems that structured systems are held far from equilibrium by maximising the energy that flows through them. Systems develop more complexity as their energy flows increase, and successful systems maximise the amount of power to the system through systems of feedback. Odum describes the energy flow as 'tripartite altruism', where a third of energy is consumed at the level of focus, with a third fed back to a lower level, and a third fed forward, or upwards to the next level. Swenson expresses this process in a similar way (see figure 16) by showing a feedback as FII and higher quality energy flowing forward as EIII.

3.5 Summary of implications for transport

The editors of the *Handbook of Transport and Development* (2015) accept the Oxford English Dictionary (Oxford, 2000) definition of transport as a verb 'to carry, convey, or remove from one place or person to another, to carry across. And as a noun: 'the action of carrying or conveying a

thing or person from one place to another; conveyance' (*Handbook of transport and development*, 2015, p. 4). The second part of the definition includes the *active process of carrying*, and conveyance and so indicates the provision of a service as well as the physical process of moving materials from one place to another. The definition does not however extend to transport as a flow – but it comes close. Using the laws of thermodynamics to explain selection processes expands possible definitions of transportation to be a part of physical evolutionary processes and so links transport with complex and orderly systems that exist because of the second law of thermodynamics.

My investigation into transport systems and energy flow challenges the idea that Darwinian selection is the evolutionary function that creates complexity without disputing that natural selection maintains order and accounts for adaptive traits in populations. This exposes a gap in the understanding of how living systems originally came about. Within that gap, transport is active in some way that is linked to thermodynamic flow. It seems that energy flows through systems are a common denominator in the natural ecology and human economy (Howard Thomas Odum, 1971, 1996a; Howard Thomas Odum & Odum, 2001) and with it transport processes. Energy flow is therefore a strong contender for being the single common denominator of all life where an energy basis to the process can be found behind many important political and public affairs issues (Howard Thomas Odum, 2007). For example, Odum finds that they can be used to select policy for land zoning, trade equity, health care and the provision of power plants. By applying thermodynamic understanding to social structures Odum provides a lawful basis to show that natural systems do not grow in a haphazard way and mean that transport within those systems is a method of feedback and feed forward of materials and information to systems at different levels of energy quality.

The structure that forms in living systems includes material self-selecting pathways that extend the 'reach' of energy collection. Self-selection of flow pathways entailed in thermodynamic processes provide part of a lawful explanation for how living systems form as a consequence of energy from the sun acting on the materials of the world. This suggests that structure could develop at the first possible opportunity where interactions are possible in thermodynamic selection processes. Transport plays a special role in a growing economy as a growth developer.

Through the work of Odum we can see that transport systems act as pumps in promoting growth and have the capacity to speed up the intake and flow of energy consumption within all systems. This capacity also appears to apply to economic systems, which when coupled with a countervailing money flow stimulates the development of material structure and complexity. Transport therefore has a role as a growth-priming activity along with marketing, subsidies to growth, and incentives such as oil depletion allowances. As an economic enabler, transport systems are costly in energy but

economically viable as long as their role as pump primers is successful in increasing the flow of energy beyond their special costs. The role of transport is of particular use during growth, where the cost of the high quality energy employed by the goods transport function as a priming activity, as described by Odum (Howard Thomas Odum, 1974) creates a flow of energy over and above the cost, especially during expanding energy availability.

Access to oil over the past century allowed high intensity and growth promoting policies and structures to flourish. Conversely transport and other growth priming activities such as advertising will become an energy liability because their high energy costs are no longer effective in accelerating energy yield. A weakness in Odum's description is his explanation that thermodynamic processes seek to maximise power. While he can describe systems that maximise energy flows as powerful, he does not convince me that the concept of seeking maximum power can be proved. Odum's approach does find that maximum power is consistent with the idea of competition for resources in Darwinian evolution and work well describes energy quality and hierarchy, and its application to thermodynamic systems as a way to explain fecundity and competition for resources.

In ecological systems, transportation is part of a physical mechanistic process that increases energy intake by actively moving energy and materials into a system. This transport activity happens within all systems as they feed higher transformity energy forward and energy back as informational controls or throughput increase mechanisms to systems at lower levels. When energy flows through the system, free energy, being energy not required for system maintenance becomes available to other parts of the system. For any work to happen there must be a large flow of energy and most of it leaves in a state of low entropy. The production of large amounts of entropy is a direct consequence of producing high energy fuel and maintaining complex systems far from equilibrium. This is shown to be the case in ecological studies, and while most energy leaves the system as low-grade heat, the other part of the story is that this flow maintains and is fundamentally responsible for high entropy entities. While not yet fully understood⁸, thermodynamic structuring acts as a driver of order with containing feedback, and feed forward transport systems. A critical analysis of transport phenomena in evolutionary development may better inform this argument, and that is the topic of the next chapter.

⁸ Some current and emerging theories about transport in active informational systems are discussed in Chapter

Chapter 4

Transport and evolutionary processes

This chapter explores the role transport plays in the evolutionary and physiological development of complex living systems. The previous chapter identified how transport processes form an integral part of order creation when thermodynamic processes act on materials. I start by considering how transport processes are represented in evolutionary theory and then consider transport activity within the context of the physical processes of evolutionary development. Recent evidence suggests that transport systems were a functioning part of the formation of the first cellular structures. I also discuss systems that have scalar similarities, and examine the mechanisms, behaviours and controls that shape transport processes found here. I explore the suggestion that transport systems and contingent processes are linked in systems that exist within an environment of high entropy flows. I explore reasons why materials depend on transport systems to maintain a state of low entropy within entities.

4.1 Transport processes in cell development

It was in 1655 that Robert Hooke called what he saw through his primitive microscope a cell (Lodish et al., 2014). When Hooke looked at a piece of cork through his home-made microscope he was the first person to see the boxy spaces that make up its structure. He compared the walled off spaces to similar looking small walled rooms in monasteries known as 'cells' (Lane, 2015a, p. 2). Lanes investigations of evolutionary biology focus on thermodynamic activity and energy potential across membranes and in doing so describes the transport process that occur (Lane, 2015b; Sojo, Pomiankowski, & Lane, 2014). Lane believes that based on his research the most influential factor in the development of the first cells was the presence of a thermodynamic flow over a porous membrane creating a potential from which some free energy emerged. The free energy resulted a potential energy gradient with the resulting proton flux leading to the emergence of cells . In microbiology the use of cross-membranes proton gradients, when first proposed in 1961, was previously unheard of and not anticipated (Lane, 2015b). It is now understood that proton gradients are universal across life on earth and as ubiquitous as the universal genetic code. These discoveries also connect transportation to evolutionary processes.

The first physical cell, with its semi permeable membrane was first theorised by Russel in 1988 and the idea further developed in collaboration with Martin. The membrane formed as an inorganic semi porous space between the alkaline hydrothermal undersea vents and the surrounding acidic sea (Lane, 2015b, p. 108). Acitina as simple pumping complexes this conjunction enabled the emergence of the first free living bacterial as the inorganic walls of the vents became lined with hydrothermally synthesised lipids. Over time the tiny interconnected calcium carbonate pores formed and developed as formalised gateways in and out of the cell structure that controlled what entered and exited the cell. This mechanism resulted in the cell becoming more able to retain free energy as the reactions fixed carbon and generated Adenosine triphosphate(ATP). Acidic oceans made the vents chemiosmotic and created a natural proton gradient across the inorganic membrane as shown in Figure 17. It is the development of proton gradients central to the ATP synthesis that power active transport in bacteria, via the development of rotating motors in bacteria that are called flagellum and are ubiquitous in both bacteria and archaea.

It is thought that the porous cell wall slowly firmed up and developed as an organic barrier (Lane, Allen, & Martin, 2010). The closed, or partially closed cell became more efficient as its entry and exit controls controlled flows that promoted ATP synthase, and so developed as a power source for the cell (Martin, Souza, & Lane, 2014). The theory that life formed in this way links thermodynamic processes with the transport of materials, with gradient leading to elementary structure. The transportation

in this environment is described as either passive or active. Passive transport is an osmotic process where materials are diffused by gradients. The more interesting development is called active transport as it uses energy from ATP to pump energy across membranes against the thermodynamic flow. What is significant about this and all subsequent descriptions used to describe the contents of cells and how they function is that they use the same words and meanings as are currently used to describe goods transport.

When cell activity was first observed, what was seen could be adequately described in existing terminology as it resembled human activities that moved goods and services around towns and

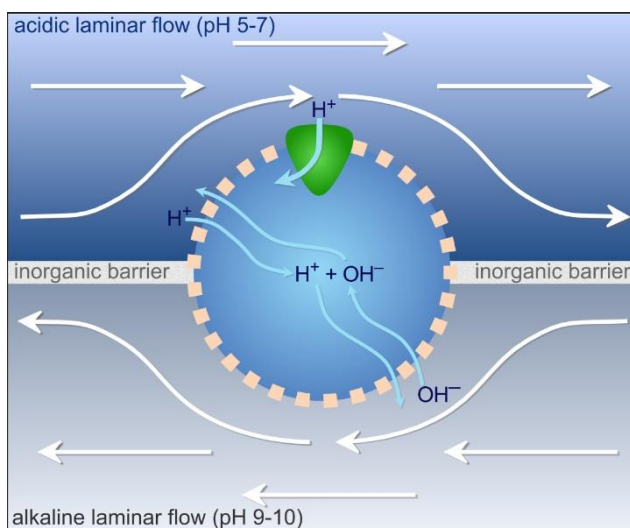


FIGURE 17 CONCEPT OF FIRST CELL

SOURCE: (SOJO ET AL., 2014)

cities. Anton Van Leeuwenhoek was the first to observe the activity of cells in the mid-17th century. The tiny spherical lens he developed could magnify objects 200-300 times making it possible to easily see the internal motion of red blood cells. He describes motile bacteria and how cilia and flagella are used by the cell to travel, move food particles, and move materials across the surface of tissues.

The technical skill that Van Leeuwenhoek used is an example of the way advances in the tools of science enabled the gathering of empirical evidence about the micro world that helps to enlighten processes that explain where we come from, what we are and where we are going (E. O. Wilson, 2012). The first cell theory used as a basis for modern biology was stated by Schwann in 1838 at about the same time that Boltzmann was coming to understand quantum mechanics.

The existence of cells was completely unknown 200 years before that. Cell theory today is still based on Schwann's observations that cells are the basic units of structure and function in living organisms. The early studies examined the nature of cells isolated from their organism and not as cells functioning as part of a larger community. Since then, answering questions about the internal and external cell cycle processes are possible through technical developments allowing observers to

overcome the technical constraints of the early studies. The development of Light microscopes for example allowed the exploration of cell structure and the facility to visualise the structure of proteins within cells. The further development of the electron microscope led to the possibility of more sophisticated exploration and in the 1970's immunofluorescence microscopy allowed isolated proteins to be identified. These technical advances revealed organelles in eukaryotic cells and more recently what specific functions the various components performed. The level of technical develop that now exists means that three dimensional structure of cells can now be observed and 'each year brings new technologies...and tools to explore the dynamics and molecular mechanisms of proteins' (Lodish et al., 2014, p. 437). During the progressive development of our understanding of cells and their components the transport terminology used to describe how materials interact at this scale has not changed. The implications of this simple observation seem undervalued when considering

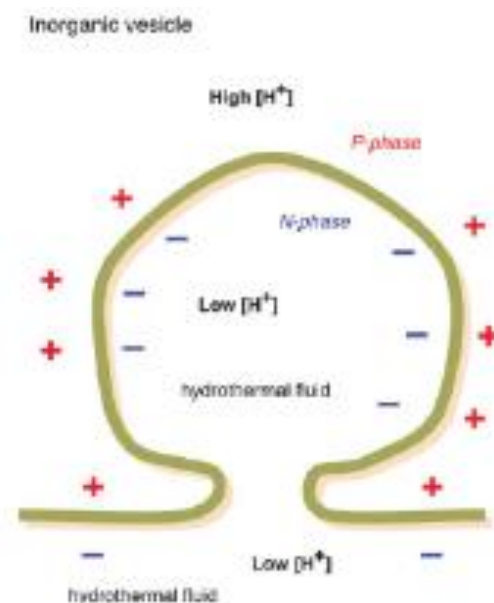


FIGURE 18 CHEMIOSMOTIC PROPERTIES OF CELLS
SOURCE: (LANE, ALLEN, MARTIN 2010)

what a theory of transport should be as ignoring it allows modern and commercial transport to be considered as a separate activity where developments and complexification are ascribed primarily to human creativity and invention. By default, such an anthropocentric view excludes a wider interpretation of the significance of transport in the natural world. The link between human innovation and naturally selected and developed complexity is a problem area with transport processes as an under theorised common denominator.

Lane considers what lawful activities gave rise to the universe and questioned how they are expressed or understood in biology. The answer to the evolution of cells he believes can be found in the science of a number of disciplines that include biochemistry, geology, phylogeny, ecology, chemistry and cosmology (Lane, 2015b). To that group I would add transportation studies. The value of this is shown in a relatively very new field of enquiry of how cells control and communicate and is an area that William Wickner, a biochemist at Dartmouth Medical schools says that it is only in the past 25 to 30 years that anything at all has been known about the proteins and actors responsible for how membrane trafficking occurs (Callaway, 2013, p. 150). Again, the access to processes at a molecular scale creates an opportunity to observe how materials act that created the first cells (Fig 18). When thought about in a different way, material interaction may provide a basis for a more material centric evolutionary explanation of how complexity develops.

The linguistic turn in philosophical enquiry is partially responsible for why the role of material processes in the creation of ordered systems. More attention in physics was given to research about tendency and symmetry in particle systems where the statistics of spatial proximity suffice as a definition of order (Gunter, 2014, p. 44). What Lane does in his research is guide us towards what Lewontin (1974, p.318) describes as a world that is processual with movement and interaction being non-random, and where 'context and interaction' are of the essence. This is consistent with Lane's belief that an informational only approach to biology can blind us to its limitations (Lane, 2015b, p. 43). His energy and flow-based approach within an active physical environment led him to consider the possibility that life started as the result of a thermodynamic process acting on matter where the activity of some molecular materials is described as 'transporters' present *right there at the beginning* of cell organisation.

Approaching the beginnings of life via processes of flow and materials transport contrasts with more conventional biological studies of the of early life that have to date, failed to focus on the significance of thermodynamic effects. In this way Lane differs by beginning his retheorising about what is required for there to be a physical basis for the beginnings of life to be found in multidisciplinary and multi-scale research about the behaviour of complex systems. It is this

approach to material systems research that guided my search for common transport structures exhibiting material feedback and communication paths that open the way for a more complete epistemological description. If transport is as significant as I am postulating, it is entangled in energy flow and subsequent waste disposal.

The importance of power stations feature in Lane's work (2009, (Martin et al., 2014), 2015). At a certain point around 2.4 billion years ago a new cell structure emerged through endosymbiosis that created a cell able to produce an increased amount of free energy flow. The more complex cells emerged at that one time that are the same modern cells found in all plants and animals. It seems that complex cells did not evolve by natural selection between competing populations but through physical interaction and an intensive cooperation that started when one cell got inside another (Margulis, 1967). Lane (2015b) identifies this as a one-time event where an archaeon enclosed a bacterium and then built mitochondria to power the further development of what became the first complex life known as eukaryotic cells. Bacteria had formed two billion years before that event and have remained in their simple state ever since and selection pressures and evolution have not altered their structure or function. It seems that once bacteria optimised the potential energy available to them they stopped becoming more complex as they had developed to a thermodynamically stable level. This strongly suggests that once energy processing is maximised within the constraints of the organism and environment, a system stops developing. In terms of selection of alternative mutations, none have been found to be more suited to energy processing and if this is the case it informs our understanding of how energy flows are managed in all systems.

The detailed mechanisms of energy harvesting developed this way are conserved as mechanical devices found universally across life. Cells now operate via biochemical mechanisms where the act of production of one gram of biomass creates 40 grams of waste (Lane, 2015b, p. 90). When mitochondria became embedded inside a bacteria cell, the resultant cooperative arrangement created access to a food source for conversion into available energy. The significance of endosymbiosis is calculated by Martin, Souza, & Lane (2014) to have increased available energy 4000 times to that available pre endosymbiosis. The modified cell now had embedded within it what is essentially a power plant and can select ways to process the flow of ions resulting in a source of free energy able to do work. It created a possibility space in which energy embedded materials could move within and between cells. With free energy now able to do work the eukaryotic cell very quickly developed structure and complexity. A significant transport related modification that happened after the power house creating symbiotic event was the development of the endoplasmic reticulum. It is found in cells with a nucleus but not found in prokaryote cells

that suggests its development came about in the more energy available environment to transport molecules on pathways within the cells new energy production capacity. The development of complexity consistent with a theory about entropy that says that structures faced with increased energy flow develop ways to resist moving away from equilibrium (Schneider & Kay, 1994). Schneider and Kay's (1994) theory of resistance and resultant structure, being that the pull of the flow towards energy dissipation selects for structure, supports the outcomes inherent in Swenson's (1997b, p. 13) proposed Law of Maximum Entropy Production (LMEP), where thermodynamic flow acts as a natural selector for complexity within evolutionary development. With the greatly increased energy flows made possible by the endosymbiosis between a mitochondrion that was somehow transported into a bacterium the resulting cell is known as eukaryotic. They are organisms with cells containing a nucleus and other specialised organelles that are not present in prokaryotes and are so able to function with far greater complexity to produce an amount of available energy. This resulted in a new stability in design with no further structural change taking place giving a singularly stable entity found across the five domains of life that subsequently developed that are almost indistinguishable under the microscope (Lane, 2015b). It appears that all cellular transport processes so far identified have recognisable architecture and mechanisms that are similar to those that designed by humans to the degree that the functioning of all transport systems can be understood using similar descriptive language.

Endocytosis is broadly defined as 'the process by which cells absorb molecules that cannot pass through the plasma membrane' (Sigismund et al., 2012, p. 273) and this discovery provides evidence that transport and the movement of matter are found everywhere in living systems. 'Endo' meaning into, and 'Cytosis' being a transport mechanism for molecules describes the action and regulation of moving nutrients into a cell through the plasma membrane as an active transport energy using process that transports large molecules that would otherwise be kept out of a cell.

The example of endocytosis is one of many medical discoveries being made that are resulting in the identification of transport and communication functions in living systems.

Often the discoveries are unintentional, or a 'by-catch' to the main medical research. Discoveries are being made in medical research laboratories such as the Rockefeller University Hospital where Palade discovered ribosomes for which received a Nobel prize in 1974 (Mellman, 2008); the first of three Nobel prizes awarded for discoveries that include new knowledge of the existence and operation of cellular transport systems. Blobel, a co researcher with Palade subsequently the underlying biochemical mechanisms leading to a Nobel Prize for 'the discovery that proteins have intrinsic signals that govern their transport and localisation in the cell' ("Opening the field of

intracellular protein traffic," 2016). Along with David Sabatini he found that every secretory protein had an amino acid sequence 'serving as a zip code'. These topogenic sequences serve as signals to control structural changes to the cell and act to move proteins to specified intra-cellular locations by sending messages and control information (Robinson & Austen, 1987) to different organelles like chloroplasts and mitochondria. Researchers have also identified the transport of material actively taking place in cells, by specialised carriers called Kinesins, Dynesins and Myosins. What is remarkable is that the descriptions of the method of transport describes movement as being 'like walking on two legs' and a representation of this can be seen in Figure 20.

The striking thing about 2013 Nobel Prize winner Schekman's description of cell activity (Callaway, 2013) is that he uses concepts and definitions completely consistent with modern commercial transport and logistics and supply chain terminology. Cell activity is described under the headings such as 'how cargo is transported in the cell; transport congestion reveals genetic controllers, docking with precision'. Cell activity is likened to 'a large and busy port' where 'bubble like vesicles, surrounded by membranes, shuttle the cargo between organelles or fuse with the outer membrane of the cell and release their cargo to the outside'. His research also examined yeast cells with defective transport machinery described as operating like poorly planned public transport. Schekman found genes in cells that control different facets of a cell's transport system and the presence of tightly regulated machinery mediating vesicle (containerised) transport. The way vesicles dock and fuse with their target membranes is described as binding like two sides of a zipper. It is easy to envisage such vesicles as refrigerated trucks sent to specific cool store docks where the dock mechanism seals around the back of the truck before the doors open and 'cargo' flows from one to the other. The actions of vesicles in this way can be described as being similar in their function to modern day shipping containers. They are filled at the post office or warehouse-like Golgi membrane structure and sent as packages of macromolecules around the cell. The transport of the travelling proteins around the cell is carried out on a road like network resembling a modern-day highway system where the main roads are called micro tubials and the smaller roads are called actin filaments. The loads carried have directional movement controlled by traffic police-like regulating proteins. The endoplasmic reticulum is the name given to what is essentially a transport network in place to deliver molecules to specific places. It seems that cells have cytoskeletal tracks and import-export machinery (Lane, 2015) and so are in the import and export business, and the operations are kept running smoothly through complex cell membrane communication including address tags of zip codes that direct their movement. These principles and mechanisms have been found to be universal, operating similarly in yeast, plant and animal cells ("Physiology or Medicine for 1999 - Press Release," 2014)

Within cells mitochondria convert food energy into ATP, which is the main currency that drive life in the cell. When cells internalised mitochondria, it turbocharged primitive cells development. Research began to focus on the physiology of cell membranes in 1950's and looked for an explanation for why concentration of ions was different inside and outside a cell (Lodish et al., 2014, p. 515). They expected there was some kind of transport mechanism present that somehow moved ions against their concentration gradients. When testing ATPase for other experimental reasons Skou, a physician researching the effects of local anaesthetics chanced upon an enzyme critical to pumping ions across a membrane. In doing so he accidentally uncovered the mechanism for active transport leading to research that culminated in a Nobel Prize for Chemistry in 1997 (2014, p.516). Skou had no intention of helping to clarify the field of active transport (2014, p. 515) and is alone in the accidental discovery of cellular activities that describe transport and communication mechanisms.

Cyanobacteria gain a rough outline of light sources and objects that it detects and then use pili, a twitching appendage to move themselves towards the light. The light-tracking power of these very small and simple spherical cells have maximum efficiency, and the phenomena is also found in rod shaped unicellular thermophilic cyanobacterium (Scheurgers et al., 2016). The scientists who discovered that bacterium sense light and move towards it (Monahan, 2016) are described as 'surprised and impressed' (Webb, 2016) with their discovery of how transport and communication are actively linked.



FIGURE 19 WAREHOUSE LOADING DOCK

SOURCE: (WIKIPEDIA MEDIA)

Active transport is described in their findings as movement 'like container shipping' and give the example of how materials movement developed in cells by describing the similarity to the way sugar was once stacked in bags in holds, it is now placed in containers and then shipped and moved by large tractor units. They describe cellular cargo packed in vesicles with motor proteins that 'walk just like a person' on thin filament of polymer roads as a way to reveal how an ancient evolutionary origin of transport machinery identifiable in modern terms. The similitude here is that cellular transport activity, performs the same type of tasks in the same way as transport systems found in our social world.

The concept of transport as a governance mechanism that regulates cell activity is found across all eukaryotic cells. More advanced eukaryotic cells have a very large array of ways to respond to positive and negative signals coming from within cells and signalling between cells. For example, Franz Halberg's proposed in 1954, that the Circadian System influences many biological processes such as sleep wake cycles, body temperature and biochemical reactions and restricts certain activities, via 'gating' at certain times of the day (Cox, 2012). The cell cycle is highly regulated to ensure ongoing cell viability, both from damage through internal operations and by protecting future generations of cells from unplanned changes. The system includes multiple checkpoints and regulators where the regulation processes are highly conserved across species, with more specific functional complexes found in more complex organisms and when regulatory processes fail, the character of the cell cycle changes.

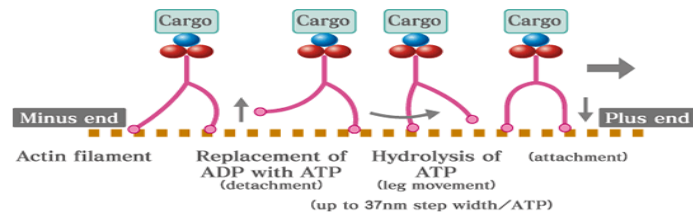


FIGURE 20 PHYSICAL TRANSPORT IN CELLS

(SOURCE: (HARAMOTO, 2010))

After the award of the 2013 Nobel Prize was made to researchers for their discoveries of machinery regulating vesicle traffic, immunologist Hidde Ploegh, a co-author of Molecular Cell Biology (Lodish et al., 2014), noted that the discoveries were so fundamental to cell biology that they had been overlooked. He commented that in teaching cell biology 'many aspects of vesicular transport are presented as if they've been there all along' (Callaway, 2013, p. 149). His comments show that this discovery about cell operation, indicates that the then current ontology passively excluded the study of transportation as able to be interactive with things in the world that are not humanly controlled. He also notes that this fundamental study was made without any urgent need to solve a medical problem – a comment that shows ontological exclusion of transport mechanisms from evolutionary research on one hand while cellular transport is used to meet a medical objective. Transport as such seems to be in no man's land as 'the biochemists didn't like the genetic approach and geneticist were doubting the biochemical



FIGURE 21 CELL TRANSPORT - MACROECULAR

(SOURCE: BIOVISIONS. HARVARD UNIVERSITY)

approach' (Callaway, 2013) The divided approach to understanding how living systems developed adds further weight to Lane's concerns about the how research in biology is framed – and while workings are partly explained, the question of why they work that way is yet to be adequately addressed. However, the combined discoveries of the Nobel laureates are considered by Juleen Zierath, Professor of Clinical Integrated Physiology at the Karilinska Institute, to be a 'paradigm shift' and discoveries that elucidate 'some of the most fundamental processes in eukaryotic cells that collectively ensure that molecular cargo is correctly destined' (2013, p. 1). Their findings are that communication sorts molecules to precise locations, and that the vesicle transport general operates 'with the same general principles, organisms as different as yeast and man' (2013, p.4). She also states that 'Without this exquisitely precise organisation, the cell would lapse into chaos'(Zierath, 2013).

A similarity of function can also be seen where materials are moved by ants along a branch highway as shown in Figure 22 Ecosystem transport. It is also not difficult to see an analogy with transport at a human scale shown in Figure 24 Mine transport, which is one of a series of photos taken at the



FIGURE 22 ECOSYSTEM TRANSPORT
(SOURCE: WIKIMEDIA COMMONS)

Serra Pelada mines of Brazil in the 1980s by Sebastian Salgado. Here we see the same physical task performed in the same manner and for the same end. Matter is being transported from one part of a system to another. The similarity is anthropomorphised Figure 21 Cell transport which is a still shot from a video where the kinesin

transport agent, being the little fellow in blue is walking a specific pathway wearing what looks like jandals and towing a large sack of goods. Figure 23 Cell transport depicts a molecular version of the same process, where we see a kinesin is dragging a vesicle along an actin filament -step by step along a predetermined path.

The pathways within cells frequently degrade and are reconstructed with networks needed and I note that the mine workers shown in Figure 24 Mine transport are using preformed but temporary ladder like pathways to guide them. As with cell pathways, the ladder pathways are constructed for a specific task, and as they are made of wood, can be taken apart and reconfigured as other pathways, or fences to guide future movements. Figure 27 shows an extreme version of this activity.

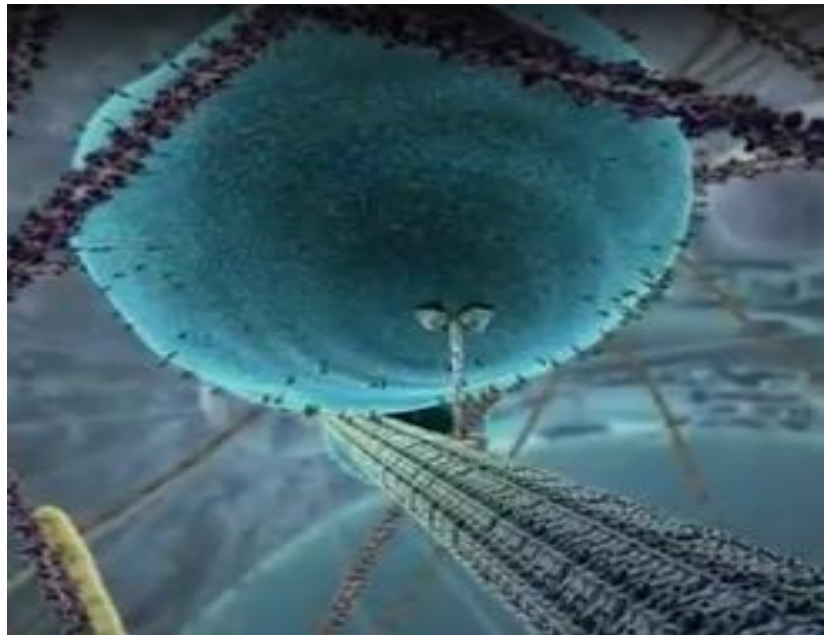


FIGURE 23 CELL TRANSPORT - MOLECULAR
(SOURCE: STILL FROM XVIVO SCIENTIFIC ANIMATION)

Intercellular transport is also described in common transport language: 'To use an analogy, between motor proteins and cars, the cytoskeleton plays the role of road networks along which motor

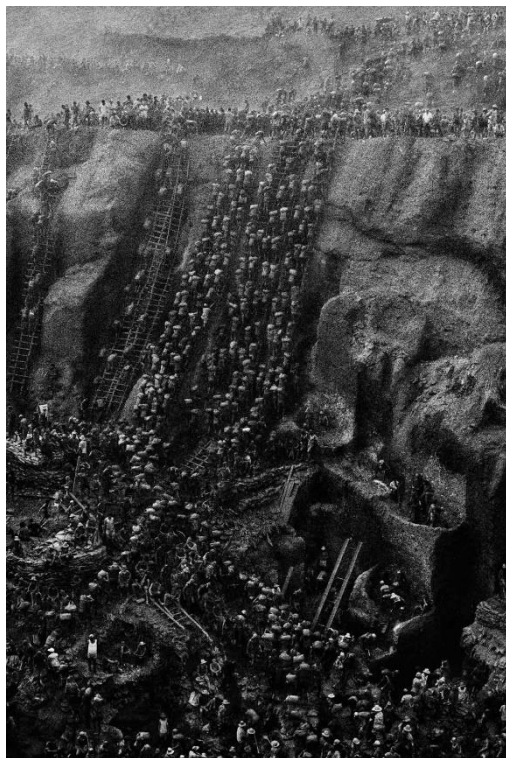


FIGURE 24 MINE TRANSPORT
SOURCE: RAREHISTORICALPHOTOS.COM

proteins move. Like road networks, cytoskeleton networks are distributed functionally along intracellular transport pathways' (Haramoto, 2010). Figure 26 Two way transport shows the two-way movement of Kinesin and Dynein moving back and forward on roadways carrying cargo as described by Haramoto. I have labelled Figure 28 'like ants on a twig' even though it is a photograph of three goods trucks on a roadway as morphologically it is the same operation as Figure 22 Ecosystem transport that does depict ants on a twig.

Within the natural world the same structure of transport could also be described as a convoy, where the ants carrying material are logistic vehicles and the twig is a supply route roadway. The scale is different,

yet the functions they perform in each of the three living systems are the same.

The analogy between cells and social systems is equally appropriate for the related communications

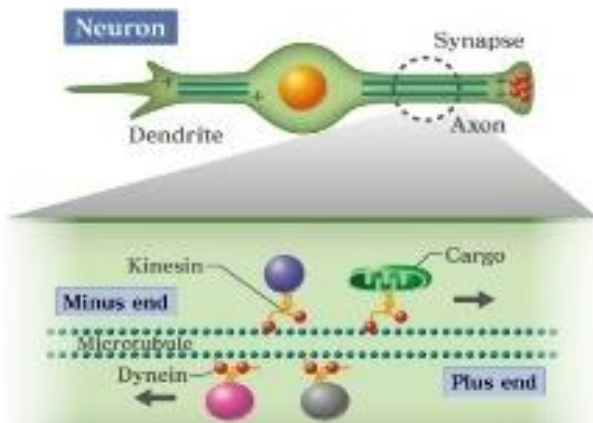
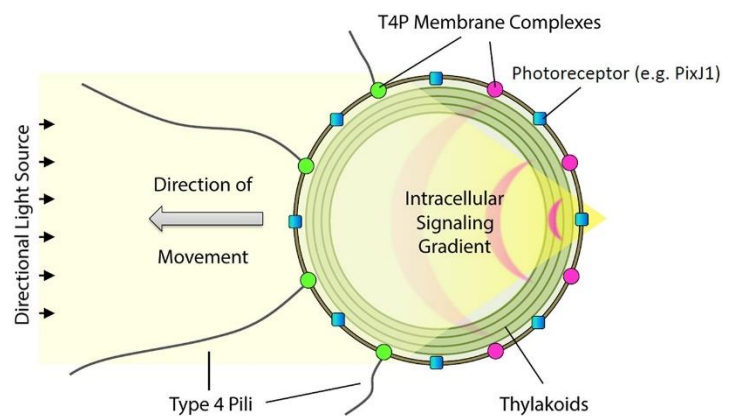


FIGURE 26 TWO WAY TRANSPORT

SOURCE: (HARAMOTO, 2010)

systems that guide freight from place to place. Amino acids ‘can be compared to address tags or zip codes which ensure the traveller’s luggage arrives at the correct destination, or a letter reaches its correct addressee’ ("Physiology or Medicine for 1999 - Press Release," 2014). The transport mechanisms of mechanotaxis and durotaxis are described in the literature although the physiological reasoning behind durotaxis, where cells are guided by rigidity

gradients has yet to be understood. Phototaxis is found in Prokaryotes and has recently been shown to be facilitate their movement towards light (Jekely, 2009). There is a more developed three-dimensional navigational ability identified in eukaryotes. Jekely (2009) says that phototaxis is known to have developed in eukaryotic cells independently at least eight times. This is a similar type of inventive necessity found in different parts of the social world, where drays and boat shapes were independently developed to meet a transport need. Jekely says that having a mechanical nature and defined steps lead to ‘pelagic phototactic navigation’ (2009, p.2797). He says that once a cell has polarity (for navigational reference) ciliary swimming mechanisms and a stable cell shape, that the step to phototaxis is relatively easy. Somehow a cellular transport need was met by a cellular artefact fit for that purpose.



● = (dis-)assembled T4P motor complex
 ■ = photoreceptor

(SOURCE:) (SCHUERGERS, LENN, KAMPMANN, MEISSNER, & ESTEVES, 2016)

From this research is can be seen that transport and communication networks require a combination of physical and informational properties and a stable form. What is it that pulls these mechanical parts together, that synthesises their properties into transportation systems?

The functioning of passive cell transporters across cell membranes controls functions similarly to an elevator in a high rise building. Just as a cell membrane allows some chemicals to move freely from one space to another through walls, a lift performs the same function. The lift door opens and allows entry, energy is used to reorganise the structure of the building, and the doors open, and the persons move out into another area. Lifts move millions of people per day



FIGURE 27 MINE TRANSPORT 2
(SOURCE: RAREHISTORICAL PHOTOS.COM)



FIGURE 28 LIKE ANTS ON A TWIG
(SOURCE: DAIMLER TRUCKS)

across barriers and are possibly the most used transport mechanism in a modern city and operate in form and function like a cell transporter.

The discovery of cellular mechanisms of perception and action include visual apparatus at different scales that use different mechanisms. An analogical explanation is given by researchers showing the fundamental similarity of functionality between cyanobacteria, the human eye, and a camera. It is thought that Cyanobacteria developed this mechanism 2.7 billion years ago. Jekely (2009) says that when researchers shone light, the bacterial appeared to integrate the information, and head off in an immediate direction. It is thought this phenomenon applies to many species of small bacteria.

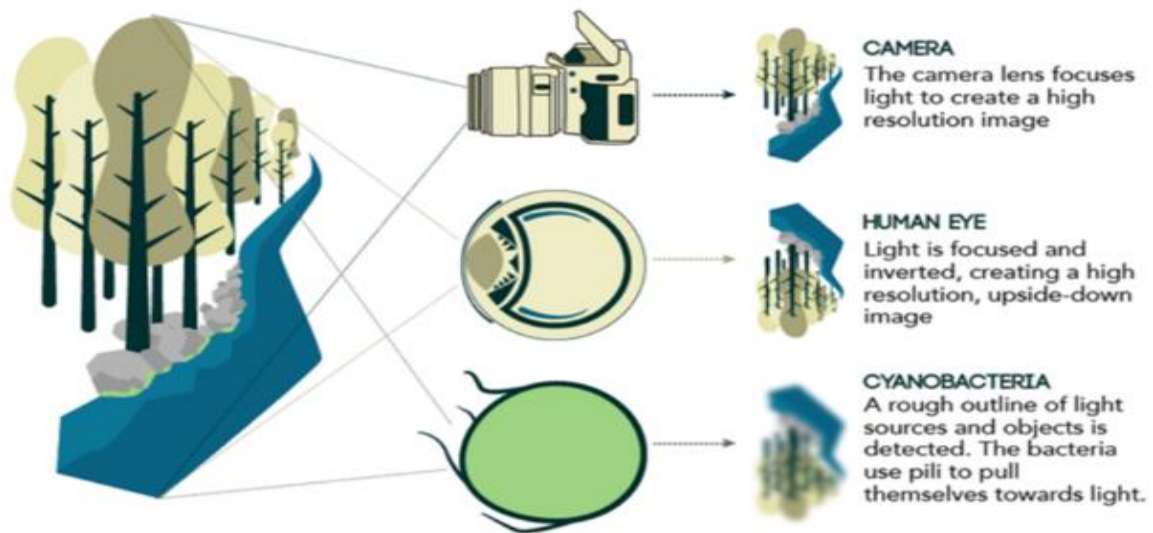


FIGURE 29 VISIONARY CONCEPTS

SOURCE: (SCHUERGERS ET AL., 2016)

Bacteria are also thought to have a sense of smell (Palmer, 2010) taking the total to four similar senses shared with humans. When confronted with certain materials bacteria can change the genes they express, which is analogous to touch. Bacteria can also use their senses to detect chemical indicating sources of food or the presence of competitors. Of these discoveries Nijland (cited in Palmer), a medical researcher says that it's:

Tempting to speculate that [ammonia] provides the bacteria with information of a nearby nutrient source, since ammonia generally is a waste product of bacteria growing on a rich nutrient source. The bacteria sense this, organise themselves in a biofilm which will prepare them for both competition with other species already feeding on the nutrient source, and enables swarming - migration via the matrix they have secreted to form the biofilm. The surprise find has implications in our understanding of the difference between prokaryotes like bacteria, which have no neatly packaged parts within their cells, and the more advanced eukaryotes that include everything from yeast to humans. If very simple organisms such as bacteria are capable of this that would imply that this ability evolved much earlier than expected

(Palmer, 2010)

The social traits with respect to cooperative behaviour are compared between bacteria, invertebrates and vertebrates by Diggle et al, (2007). Motility, or swarming for group derived benefits is found in myxobacteria that exhibit self-organising behaviour that includes communication among themselves in response to the environment. Ants and termites also exhibit

this behaviour. To protect against adverse conditions myxobacteria as do most microorganisms have mechanisms that enable them to cooperatively build an extra cellular matrix, or biofilm. Building is communicated via stimuli and response with the rest of the population as do some insects when working out where to nest. Diggle et al. give the example of burrows, nests, hives, and cities – so linking human social behaviour to similar cellular behaviour. Chemical stimuli and response, or quorum sensing within a population enable many species of bacteria to coordinate behaviour, in a similar way to pheromone production in many social animals such as pigs and rodents, with evidence being found in 2001 of a human response to the chemosensory signalling (Savic, Berglund, Gulyas, & Roland). Similarities in enhanced growth and colonisation in the form of foraging and hunting for nutrient acquisition are drawn between the actions of many bacteria and wolves, lions, and again, humans (Diggle et al., 2007).

While his research objective is primarily aimed at finding new ways to prevent bacterial infections, it also provides proof of analogous bio mechanical processes used in or by entities with transport systems. It provides evidence of entities that exist that support ontology of transport that includes naturally occurring logistics as a natural. Currently the expansion of scientific knowledge, technological change and economic growth seems to have made communities more confident in the belief that environments can be managed, with the goal being efficiency and standardisation. The world view that maintains transport is derived demand in a technical world also supports the framing of environmental problems as administrative and technical challenges at a sub political level (Lebel, Anderies, Cambell, Folke, & Hatfield-Dodds, 2006)

Transport phenomena is taught in different ways and different levels with a growing interest in its physical significance through the closely related topics of momentum, energy, and material transport. The basic equations physicists use to describe fluid dynamics, heat transfer and mass movement are closely related, and problems can often be solved 'by analogy' (Bird et al., 2002, p. 2). In describing the physics of transport phenomena Bird et al. (2002) find that the molecular mechanism is very closely related as all materials are made up of molecules, and the same molecular motions and interactions occur at the macroscopic, microscopic, and molecular level. The cover of their book includes the diagram shown as Figure 30 Analogy of the scale of the physical, and shows the relation that they use to solve problems with physical similarities 'by analogy' (Bird et al., 2002, p. 3). In their field Bird et al. say that properties described by molecular theory are used at the microscopic level, where equations developed at the microscopic level 'are needed to provide some input in to problem solving at the macroscopic level'.

In this section I consider whether there is a physical analogy between the structure of cells and social structure. At an extreme, how can transport ontology inform our understanding or the difference of city structure between Venice and Los Angeles. Transport is the enabling of the process through active physical and directional chemiosmotic processes that dissipate potential energy, and in the process select paths that are the development of structure. There is a similarity of directionality, active complexification, and the concentration of structure within a defined space that I will describe and illustrate as being a similar process at the scale of social systems.

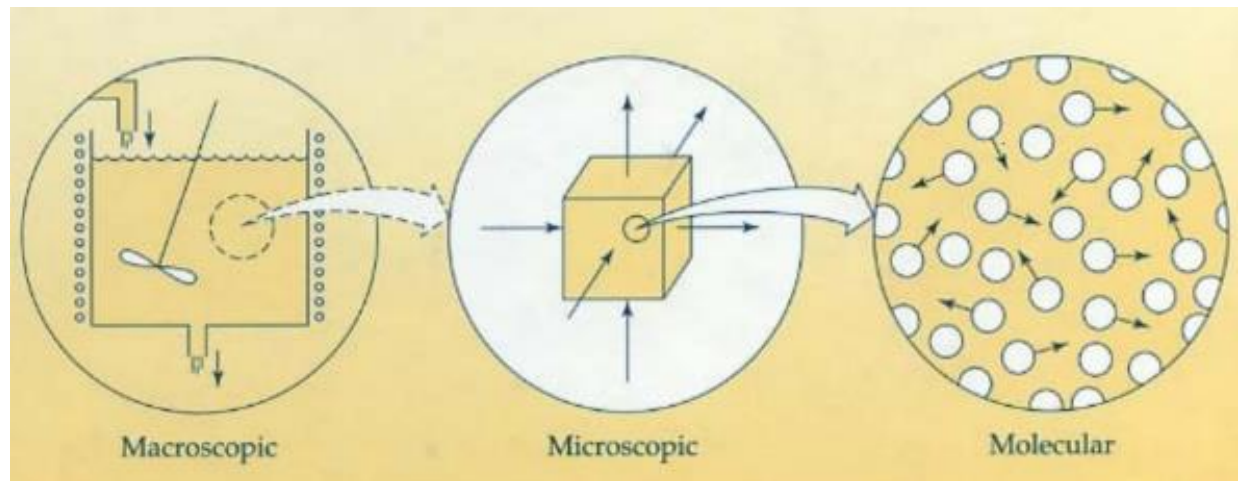


FIGURE 30 ANALOGY OF THE SCALE OF THE PHYSICAL

(SOURCE: (BIRD, STEWART, & LIGHTFOOT, 2002))

4.2 A materially active account of structuration

In Lane's attempt to make sense of how atoms can make living structures he refers to this uncharted area where he considers that life is a side reaction to of the main energy releasing action. He identifies a physical process occurring in a natural space that slowly differentiates into a defined space, not unlike early London being territorialised by the building of a wall by the Romans in about the year 200AD following the building of the fort defining a singular point. What he finds is that electrons are physically transferred from one side of a barrier to another, as a physical and not chemical process. It is an act within physical constraints suggesting that life is a physically motivated act with physical constraints, one of which is transportability. The physical business of living is a factor that must be allowable in transport ontology as is the need for large scale energy demands for energy that is converted by a detailed mechanism that is not plain chemistry. Lane also identifies a flow and a flux in the form of mineral catalysts and natural compartmentalisation. There is not a clearly known or agreed physical/mechanical/chemical or epistemic tool that provides a lawful and disprovable basis for what he is finding. He uses 'invent' (Lane, p152) regarding the new pathway. He leans towards an outcome in terms of natural selection but falls short of describing what the 'striving' in Darwin's theory is in this situation. He has no clear understanding of how the apparent

information of 'aboutness' of the cellular behaviour comes about. It is not information-based construction but construction coming about through transportation and flows that are physical and directional. The proposition here is that if a system is self-energy sustaining then it has an epistemic dimension and acts on information about its environment and is not just a mechanism responding to data. From this I suggest that transport as a flow mechanism is a physical enabler of both passive and active transportation within living systems. It is part of the process of the emergence of meaning and a visceral evolution of intentionality in the epistemic dimension. The process described entails structural building of pathways and mechanisms of action and perception that maximise energy flow to the benefit of the living organism.

This lawful process does not rely on total randomness and chance in the development of structure and complexity. Systems that are successful in their development maximise opportunities open to them within the structure of that space, and in doing so exhibit a form of physical, or chemical intelligence acting on the selectiveness of systems maintained within an invariant ambient energy flow. A model of this process would merge and blur the boundaries between physics, psychology, and biology via flows of non-equilibrium thermodynamics, chemiosmosis, and physical intelligence. Transport can then be analysed and theorised in terms of the operation of the organism – environmental system, the instantiation of self-other.

It is helpful to consider the birth and development of London as though it were a primitive prokaryotic cell⁹. London was established on the north bank of the Thames by the Romans as it was controllable crossing point, as the river was narrower at that point because it flowed between two small hills. The first settlement was surrounded by a ditch and earth rampart with a wooden palisade on top. The crossing point was formalised when a bridge was built over the Thames. After being ransacked and burned to the ground by Queen Boudicca, the rebuilt town was better protected by a wall from further invasion. A thriving port developed which saw goods imported and exported. This development, where a separated space was created by a ditch and earth walls is analogous to the development of the first physical cell. Invasion and pillaging would mean that little structure would develop at first.

The occupants now address the same questions that Lane posed about how cells keep the differences between inside and out. This was achieved by controlled entry gates. There is no need in

⁹ The following summary of the reasons for the location of Thames is drawn from a number of sources (e.g Wood, 1982)

this analysis to consider a neo-Darwinian focus on an informational approach to biology when explaining how the cell or the city developed. The creation of a living town is about flows, earth, and connections.

When viewing a map of the general layout of the early city of London it is hard to escape the visual form as resembling that of a cell (Figure 31). The city wall keeps the inside separate from the

outside and a permeable barrier maintains flows via the river Thames, which brings food and takes away waste. Of particular interest are the portals around the perimeter of the settlement, both on the river and as gates for transport port control. City gates regulate the flows with functions including the isolation of social parasites, in the form of gates to prison. I note also that environment considerations caused structure such as the specialised London Bridge as a gateway. Internal of the

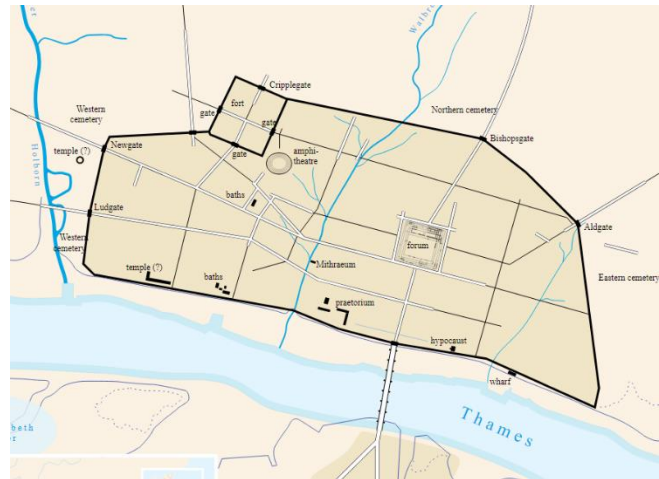


FIGURE 31 THE ROMAN 'CELL CITY' OF LONDON

SOURCE: WIKIMEDIA COMMONS

cell we see transport and flow pathways being roads and rivers, with internal transport paths. One would think that this structure with the energy flows of the time created maximum health and power to the cell. We can view this development as geological as it concerns itself with dynamical elements (energy flow, nonlinear causality) as similar to non-living structures. For cities on the sea border an energy source for developing complexity is provided by the trade winds. I would consider early London and Venice to be 'prokaryotic' in their structure as they lacked mitochondrial engines: *Engines that you feed*. The 1800's brought about new intensification of inflow of energy to city cell structures, through the exploitation of fossil fuel. The role of transportation quickly developed and was powered by the potential energy available to increase flows with resultant changes in form.

4.3 Cellular transport features found at different scales

Discoveries over the last twenty years show that endocytosis is far more involved than molecule absorption and a more precise definition of cellular activity is given by Sigismund et al. as:

A vast program, deeply ingrained in the cellular master plan and inextricably intertwined with signalling, which constitutes the major communications infrastructure in the cell. As such, it governs almost all aspects of the relationships of

the cell with the extracellular environment and of intracellular communication. Its evolution constitutes, arguably, the major driving force in the evolution of prokaryotic to eukaryotic organisms.”

(Sigismund et al., 2012)

Cell signalling events in living cells are described as semiotic, as the biological information is decoupled from its matter and energy. Cellular advancement is influenced by opportunities in the environment, but mainly by signalling events, where the system can modify or rewrite its own rules (Navarro, Goni-Moreno, & Marijuan, 2010) to meet the demands of the environment. It is a physical information system: that is information that alters molecular interaction and creates mechanical outcomes. The level of complexity of information being discovered supports physical intelligence within living systems other than just at a human level. The decision processes of cells follow thermodynamic principles, and this also suggests that the best descriptions of some forms of energy flow are not primarily as a commodity but as a connection between the material and the living. That connectivity is being explored in research that is advancing information science, identifying the structure of information needs and the nature of signalling within cells (Del Moral, Navarro, & Marijuan, 2014a; Marijuan, 2009).

Transport systems help maintain the persistence and identity of living entities themselves, and in their relationship with their environment, and with other entities that so defines them. Transport does this by facilitating the movement of materials and energy and guided by information about the environment received through communication. Transport is therefore requisite to maintaining the organisation of living and non-living systems as both are dependent on outside energy fluxes to maintain their identity as a locally reduced entropy state.

Marijuan suggests that the deeper understanding of the level of transport and communication offers a way to merge the descriptive intention of autokinesis, along with other descriptors such as self-transcendence, autopoiesis, and autogenesis into one project where ‘we may say that the living existence is *informational*’ (Marijuan, 2009, p. 371). Energy flows and with signals from molecular structures that produce ‘meaning’ offer blueprint information for autokinesis and similar mechanisms. Marijuan believes that what is being discovered and reflected in the precise definition given by Sigismund above, could lead to a transition in the understanding of transport, communications and the informational content in cells, similar to that made when science and technology collectively unlocked an understanding thermodynamic flows and properties of heat and irradiative energy as well discoveries of quantum mechanics (Marijuan, 2009). Sigismund et al.

(2012) are discovering things that are difficult to reconcile with the traditional view of cell operation which is understandable as the model under scrutiny is one that has its roots in the technical understanding of cells available in the 1830's. The complexity of cellular signalling, messaging, regulation, molecular machines, and self-assembling complexes is stimulating questions about what the new bio information means, and so is an area of growing interest (Sigismund et al., 2012).

Research that focuses on regulatory actions that guide the overall network and movements between the inside and outside of the cell is revealing new dimensions of bio information over and above research into expression of individual genes. An example of this is the Endocytosis Transcriptional Regularity (ETR) Network of *M. tuberculosis* shown in Figure 32 that covers about 35% of the genome (Navarro & Marijuan, 2011). There is a clearly hierarchical organisation in the structure that contains various discreet communities that are in communication with each other. Marijuan says that a simple change at one point can change a vast array of functions and activities.

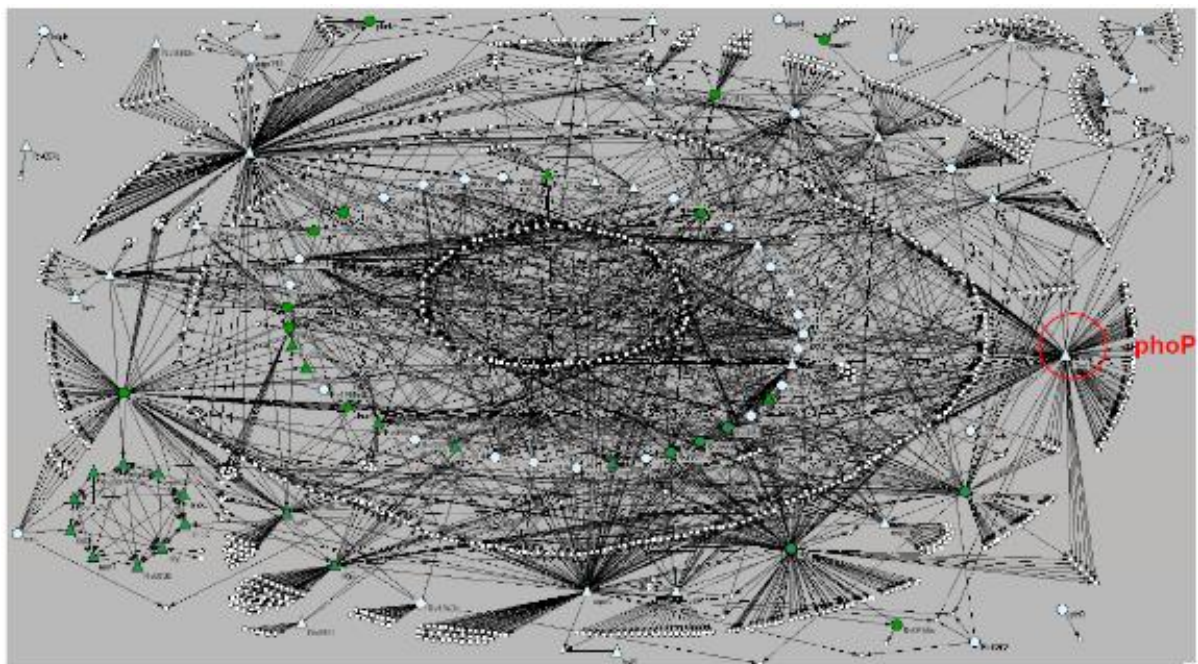


FIGURE 32 THE ETR NETWORK OF *M. TUBERCULOSIS*

SOURCE: (NAVARRO & MARIJUAN, 2011)

Note that this network pattern has a similarity to shipping network¹⁰ as shown in Figure 33, being flight scheduling for part of the USA airspace covering the activities of two airlines. The idea of a simple change in this instant could be the closing of an airport by fog requiring diversions and the implementation of other activities like bus trips between airports, accommodation near the airport

¹⁰ For an interesting set of hand drawn airline networks showing a similar abstract architecture and hand drawn by Jim Liu see <https://news.airtreks.com/2009/11/hand-drawn-airline-route-maps-by-jim-liu/>.

and information to affected passengers. To make networks like these operate requires signalling guidance to put route plans into action in response to changes and emergencies.

It seems that the systems in cells that can react to specific events in the environment require more than a source of energy for the complex life-cycle reaction to continue. There also must be a continuous flow of information about the environment to keep structures in a permanent state of



FIGURE 33 MAP OF SHIPPING NETWORK

(SOURCE: WWW.KILN.DIGITAL)

flow through storage, waste removal, and process management that have commonality to self-organising systems. Cells appear to be able to ‘grab’ or ‘abduct’ information from the environment and make ‘distinctions on the adjacent’ (Marijuan, 2009) or a new level, or even dimension, of informational integration within living systems and their immediate environments. The development within science of a ‘composite informational construction’ of information activity indicates a role that is much more than isolated bits of information or signals sent and received to one that is more like a co creation of information driven integrated adaptation of entities within environmental entities. Research like this is leading to a new way of understanding how bacteria interact with entities in the world. It is as a proto-phenomenon of biological information and this seems consistent with modern developments of transport entities as parts of a larger conglomeration of logistics, communications storage and response systems within the communities served. By using the tools of systems biology and network science we can start to translate the whole conceptual cluster around information in rather precise molecular terms.

Our understanding of information and guidance towards a more genuine informational approach to science may be aided by making sense of biological information systems, and the role transport has in those systems. It seems that cells operate is as a collective problem solving dynamic structure

operating in a network and at different quality levels that continuously exchange information. What is found in cells is biomolecular information that is constitutive, generative, and communicational. Of this Marijuan et al. say 'the whole productive –informational processes culminate in a regularity of a specific cell-cycle open to the environment, both in terms of energy and information' (Marijuan, 2009, p. 371)

Cells live by systematically responding to signals from the environment and meaning comes from interruptions of cellular self-production 'flow'. From informational systems found in cells it is likely that informational systems are central to how entities organise themselves and 'transcending adjacency would be a permanent driver of biological and cosmological evolution' (2009, p371).

The identification of bio information pathways that molecular recognition is shown to have, alters chemical structure in an adaptive coupling with the environment, and when added to the sorting and intensifying aspects of energy flows discussed in Chapter 3 entangles the active capacity of matter to act on itself and on and with other matter. What the informational aspect of this offers, Navarro and Marijuan argue, is that the 'multi-domain embodiment of function in enzymes and proteins allows for configuration of a new type of collective computation within an evolvable quasi-universal problem solving constructor'(Navarro & Marijuan, 2011, p. 397). The term universal constructor aligns with Odum's systems diagrams, and as I argue in later chapters, DeLanda's abstract diagrams. Marijuan's research group identify signalling system mediated adaptive coupling with the environment as possibly being a semiotic reference frame for a reformulated informational cellular theory. I note that the reference frame includes the appearance of meaning, value, fitness, and intelligence applied to systems without human intervention. The similarity of cellular transport and possible molecular intelligence with airline routes, that are themselves assemblages of communication and materials transport, is consistent with the possibilities of general similarities in the architecture of structures of quite different material make up. This supposition is also consistent with my research themes that explore how flow, scale, and natural intelligence, share a similitude of processes in many living systems. Free energy became available with the invention of hydrocarbon powered, thermodynamic engines that you feed. I suggest that a similar endosymbiotic event could be said to have happened at the time of the industrial or energy revolution, where engines you feed became embedded in social systems and greatly increased the amount of free energy available to the system. One outcome of that revolutionary and evolutionary event was the displacement of manpower as the basic currency of work output, and consequent undermining of Marxist theory of labour, and its replacement in terms of the mechanical output of dishwashers, diggers and all manner of rotary motors adapted to replace manual work.

At the turn of last century bacteria were considered as unicellular organisms that existed in isolation to one another. This view is analogous to Boltzmann's molecules acting as independent agents with interaction being at a superficial same cause same effect level. What is now known is that bacteria are highly interactive and 'possess an extraordinary repertoire of intercellular communications and social behaviours' (Diggle et al., 2007). Some researchers suggest that those behaviours look much the same as the behaviours of social insects, vertebrates and humans (Williams, Winzer, Chan, & Camara, 2007). The stable natural whole of an entity, at the level of a molecule, plant, or animal – appears to be a combination of interacting parts and bio-information. The complexity of information juxtaposes information phenomena of the organised collective entity with other entities with an interrelating environment in an autocatakinetic way that functions to raise the energy quality of the information system.

4.4 Evolution as a material activity

Perception and action are an achievement of the animal environment interface.

Perception is guiding action

(Carello & Turvey, nd)

In chapter 3 I described how Swenson developed and combined a broader conception of evolution with an epistemic view that in contradistinction to an interpretation of the second law as a statistical averaging of the tendency for randomness and disorder is considered reversible and defined functionally as leading to a state of disorder in the world. Following Prigogine Swenson argues that entropy is linked to the arrow of time always taking flowing by the fastest route for energy dissipation and by that selecting process is an order producing architecture. The importance of this is that spontaneous, or naturally occurring order is not infinitely improbable as stated by Boltzmann. Odum describes successful systems as those that maximise power through maximizing energy capture, whereas Swenson attributes their success and persistence to an ability to maximise entropy production. Both understand that order arises in the presence of energy flow in a way that is consistent with the energy laws with no reliance on external intervention of any kind.

I described the autocatalytic and autocatakinetic processes that Odum and Swenson reason must exist in self-sustaining systems. Swenson's work considers the way that thermodynamic selection principles act in a physical way in living systems. The mechanism central to his argument is autocatakinesis, the architecture of which points towards a unified theory of evolutionary ordering (Swenson, 1991). England (2013), an assistant professor of physics at the Massachusetts Institute of Technology, continues Swenson's line of argument saying that natural selection is a special case of

evolutionary process. He believes that there is an energy source constantly surrounding atoms that results in a natural organisation of what we observe as the physical characteristic of life. What drives this is the system's ability to disperse great quantities of energy when driven by an outside source such as the sun and bathed in the right atmospheric or oceanic conditions (Wolchover, 2014). England recognizes the difficulty that statistical physics has with living systems because they are far from equilibrium and 'therefore need not obey a simple Boltzmann probability over microscopic arrangements' (England, 2013, p. 139). This means there is an unconstrained diversity making it difficult to home in on a general theory. His work in this field so far shows that the 'microscopically detailed, quantifiable relationship between irreversibility and entropy production ...has significant general consequences for entities far from equilibrium macroscopic processes' (2013, p139). England says of his research that 'what we have glimpsed here is that the underlying connection between entropy production and transition probability has a much more general applicability, so long as we recognise that 'self-replication' is only visible once an observer decides how to classify the 'self' in the system' (2013, p139). Transport and structure may well be entangled in what is meant by this self-other process and evidence of this requires a better understanding of the general relationship of heat, organisation persistence and that this is what the tools of molecular biology apparatus are starting to illuminate.

The evidence of transport and communication processes found at a cellular level provide is starting to change the idea that evolutionary processes are reliant solely on a gene centric view central in neo Darwinian theory. The discovery of an information based genetic activity further informs Darwin's thinking that led him to seek a mechanical inter-actionary explanation for evolution, reasoning that such actions could lead to, or cause adaptation in a population (Hoelzer et al., 2006). An ontology that commits to a natural order producing world of energy flows and entropy as a selective process, can expand our definition of goods transport to encompass more than just that of being an anthropomorphic tool of resource exploitation.

The production process creates new entities, and combinations of those entities create new entities with identifiable production processes includes new the appearance of novel transport entities. The molecules continue to function as molecules and undergo reactions in gradients generate form in matter. These are biological and chemical processes that offer insights that physics alone cannot offer about the way that new things can come into existence that exhibit new properties that are not found in their component parts. What can be said about this is that the reality of objective phenomena can be confirmed by a posteriori science through being observed with the instruments of science within the domain of molecular biology. This requires that the findings are verified across

a range of laboratories, by technicians using powerful microscopes to observe activity that exists independently of the human mind.

Wilson considers 'luck' and improbability as key elements of evolutionary development. He says "the reason is simply the *extreme improbability* of the pre adaptations necessary for it to occur at all" and later the remote coincidence "to have made every one of the required *lucky turns* in the evolutionary maze" (E. O. Wilson, 2012, p. 45 my italic) If Wilson's view is the right one then there is unlikely to be any consequential acceptance (or otherwise) of common factors with social evolution. Wilson's reliance on chance and luck is consistent with still tightly held view that 'exactly the right genetic changes' led to 'a stroke of luck' that is humanity (E. O. Wilson, 2012, p. 50). His own work recognizes that genetic changes are around disease, local climate and food changes – important; but not passing Swenson's test of 'putting living things, including humans, back in the world and recognizing living things and their environments as single irreducible systems' (Swenson, 1997a, p. 43) If we accept that humankind is 'in the world' and we are evolving as part of the same self-organizing processual system as everything else, then our understanding increases of what ultimately successful energy flows through society will be like. He makes one reference to the speed of change when resources are abundant, but by and large views evolutionary processes as non-thermodynamic. In doing so he misses out on the centrality of Swenson's perception – action account of development as when 'whole system evolutionary changes designed to increase territorial reach and influence' (Swenson, 1997a). The importance of this evolutionary view for goods transport is that it accounts for rich matter brought to centres of social existence. Structures that Wilson believes came into existence because 'altruistic cooperation protects a persistent, defensible nest from enemies, whether predators, parasites, or competitors', and that 'members of groups belong to more than one generation and divide labour in a way that sacrifices at least some of their personal interests to that group' (E. O. Wilson, 2012, pp. 140-141)

A focus on energy flow and material processes begs the question of whether Darwin's now 300-year-old natural selection theory is a partial description as a special case of a larger and more inclusive evolutionary theory about the development of the living. If advances in micro science discover mechanical functionality that can be described adequately by macro structures such as logistics hubs, and topological communication systems, then the discovery of the existence of these advanced structures helps explain other primary evolutionary processes that take us from the first cell, to a diversity of living things that Darwinian selection can then act on to ensure the most robust combination of traits maximises life at that time.

Darwinism may owe its ongoing hegemony as the leading explanation of evolving progress to providing a view of the world that lends support to Victorian capitalist and global industrialisation forces that emphasize human ingenuity and innovative activity while treating material explanations, and associated transportation, as external to evolutionary process. Seen in this way a business focussed social structure negates the need for a meaningful explanation of the transport function. This view is supported by the literature as shown in Chapter two, where there are few theoretical suppositions about goods movement found in any discipline. Instead the focus is on an evolutionary theory, where the ascent of man relies on random gene mutation and increasing fecundity – the survival of the fittest. While Darwin's natural selection mechanisms are becoming progressively better understood, debate remains over where Darwin's competing populations first came from. Notwithstanding Darwin's reliance on God as creator, his theory leaves questions on why life is like the way it is, unanswered. If transportation is found to be actively part of the formation of the last common ancestor, then identifying how fundamental transport's role is in all thermodynamic systems may be the next big thing in understanding continuing evolutionary process and progress.

What is found in ecological and cellular systems challenges the Boltzmann casting of entropy as leading to a progressive disorganisation of the physical world. What would a non-Boltzmann based theory of transport have to account for? It would have to account for why extension happens in specific ways in different living things, and why once a certain capability is reached complexification stops. Once a new structure is in place then any changes are relatively minor adaptations. Those adaptations would need to be consistent with the overall structure creating mechanism, maintain change within that overall structure, and allow extinction when the overall structure is no longer able to interact with the energy flow in the environment. To create a more robust and scientific basis for the defence of self-building systems requires the centrality of a mechanism that somehow self builds, without human intervention, and builds structure of a certain type and includes transportation systems. It is a field of study excluded from the neo-Darwinian natural selection explanation of evolution but the resolution of which may be central to understanding transport systems. An understanding of how potential is dissipated adds credence to a lawful selection process and wider understanding of evolution. The barriers are high. Hoelzer finds a reticence among evolutionary biologist to entertain cross disciplinary or any non-Darwinian theory. This is seriously limiting to developing transport theory as transport is a cross disciplinary mechanism that expands evolutionary thinking beyond natural selection as an explanation that encompassing a whole systems perspective (Hoelzer et al., 2006). Research in a number of disciplines identifies that life exists far from equilibrium when understood as sustained by energy flow through the system (Chaisson, 2005). While molecular biological research is answering questions about what happens

when transport systems fail in cells, there is also opportunity to consider the transport aspect of microbiological research to identify how to design and govern transport processes within healthy social groupings.

Transport theory becomes interesting in a world where systems are seen as striving to maximise entropy and select the most efficient pathways to do so. The industrial revolution depends on such a striving mechanism in the development of steam power through finding a faster way to degrade energy by harnessing it as locomotive power. In this chapter I have shown how transport as an active participant in the evolution of the world and so widen the scope of possible evolutionary mechanism to account for the universality of the transportation function.

Odum theorises about the role and 'meaning' of entropy and there is comparability between the concepts and meaning between 'maximum power', and 'maximum entropy'. To reiterate, what Odum found is that "during self-organization, system designs develop and prevail that maximise power intake, energy transformation, and those uses that reinforce production and efficiency" (Howard Thomas Odum, 1971). This means that systems that maximise their flow of energy survive in competition. The question this raises is by what mechanisms is it that systems organize themselves *naturally* and how is transport part of that process?

4.5 Chapter summary

In this chapter I searched for and considered transport processes that are found within physical, and evolutionary processes. There are identifiable transport processes found in geological, cellular, and ecological systems. Advances in science provide more complete descriptions of how material processes that led to the formation of material objects in the world. The recurrent themes of thermodynamic and chemical gradients are widely identified in these processes.

Descriptions of transport within cellular activity include communication of routes and cargos, energy flows, and the interface between cellular components and control of borders. Cells need to transport proteins within their structure or to compartments within the cell (intercellular) and also out of the cell. The movements are directed to the right location by signals that govern cross membrane movement. The messaging is an integral part of the performance of the cell in total meaning that transport here is not a 'derived demand' but an informational activity integral to maintaining the cells persistent state. In evolutionary and molecular studies there is evidence or some very material processes containing active transport. Those processes are recognisable and functionally similar to modern freight transport and logistic process, and so there is a basis for theorising about the role of transport from the beginnings of life through to rapid parcel delivery

services. A metaphysics for this requirement is a broad church akin to Lane's question about cell development also addresses the macro world with appeals to universal questions about life, and addresses the micro, in questioning how energy flows power mitochondrial motors that turn and in turn power transport mechanisms. The finding that cellular systems are transport intensive and communicative in several different ways that have been refined over billions of years for different purposes Darwinian evolution is not focussed on how life began as to do that would require competing earth systems upon which natural selection could then act

What the research into material processes may provide is a clearer understanding of the processes by which the first cells came into existence. They are likely to be processes where the features of existing molecules combine to create new structures with emergent irreducible properties. Research has found that transport processes are regulated at the boundaries or edges of each cellular territory is a key part of the health and functionality of individual cells and cellular systems. Control at this level includes 'feedback' from a central cellular control point, meaning that a systems boundary is managed by several internal and external signals. These control systems are also found to operate timetables and set timeframes of micro goods transport systems. The overall state of larger organism is under this type of active transport control that regulate the medium to longer term survival of the cell.

Eukaryotic cells have been in existence for over two billion years during which it is likely that their transport and communication systems developed as the most optimised and efficient on the planet. Life is contingent upon material and energy flows where life is embedded in a physical environment where transportation makes up the interactions. When considered this way, living systems are not separate from their surroundings but are within the space time dimension. Causation in this setting appears to be a process where properties of one entity acts on properties of another. It is a function of interaction driven by systems that always select pathways to maximise entropy production. Matter, energy, and physical information are what are required for building structure using some form of autocatalytic or autocatakinetic process.

Researchers working at the scale of molecular structures either actively or passively report the presence of highly developed transport processes within these material systems and describe how they engage in the creation and regeneration of new structures. The research insights gained about transport this transport activity are often co-findings to the main point of the research. That suggests the research methodology has no experimental bias in setting out to find what transport is or does at different scales. This 'bycatch science' is a very favourable development for my search questions as I postulate that an understanding of transport in any situation must be totally

integrated with a co-dependent understanding of the material environment, their properties and history of becoming. Cell logistics, endocytosis and signalling discoveries could expand the theoretical conception of transport through finding connections between transport, communication, and material interactions. This suggests that the theorising transport in evolutionary development terms, along with thermodynamic properties identified in chapter 3 will lead to metaphysical understanding of how transport, energy, materials, and information work together.

The way medical and molecular researchers define transportation in cells is of particular significance to the theoretical way to account for transport phenomena. I am particularly intrigued by the also natural and unquestioning way that researchers label molecular movements and processes with standard descriptions of social and commercial transport systems. Transport is common to all these disciplines and enriching a metaphysics of transport will help unify an understanding of effective material feedback processes and communication paths within systems. A more complete theory of evolution must include an explanation of how processes can develop from within one set of resources. This means that the evolution of the Earth began within a population of one where pressures were not just selective or competitive, but also emergent. Transport is part of that activity bringing materials together in an active way, often driven by gradients. The results are unanticipated and unexpected resulting in new and novel emergent properties not found in the constituent materials. The active nature of material evolution in geology for example raises the question of how to think about active and immanent properties of materials manifest in the creation of form – especially when this requires an active transport role in the assembling process.

directs my investigation now towards finding similarities in human social practices and decision making. It leads me to question the importance of the relevance of the material setting of social decision making and the way that institutional coding influences behaviour and practice. I say this in terms of the feed forward and feedback controls that are found in complex systems, and the way that, for example social processes of praise and reprimand operate within social territories. If transport processes are part of the definition of activity within a cellular territory, then it is possible that transport, territory, and rule enforcement shape social structure as well. Understanding this therefore requires a metaphysics of both transport and social structure. This type of transport infused material interaction can inform an ontological commitment about what there is in the world to allow their existence.

There are similarities and regularities in the way transport systems function at many scales in natural systems. The mechanisms can be described in similar ways to social transport systems. The

challenge now is to consider whether there is a metaphysics common to all transport, or at least to all flows of matter in the earth system. The autocatakinetic self-organisation of matter means transport systems move energy from one place to another, both up and down energy gradient, within processes that increase energy quality in specific places through creating the maximum entropy flow. Energy flux will select entropic pathways in evolutionary processes, at a cellular level, in ecological systems as well as in social systems.

I have described the extraordinary changes to transport systems enabled by technical and scientific advancement, as well as the increase in computational capability that has changed communication and information technologies. An ontological commitment requires understanding and further exploration of physical systems, information systems and 'natural intelligence' that have here only been coarsely described. Focussing on transport as an active evolutionary and order producing informational process could be applied to the conceptual structure of social governance in a highly informational world. If we accept ontological assumptions and theories based on those assumptions it could inform research on planning, transport development.

Chapter 5

Committing to an ontology of transport

I can see no other escape from this dilemma (lest our true aim be lost forever) than that some of us should venture to embark on a synthesis of facts and theories, albeit with second hand and incomplete knowledge of some of them—and at the risk of making fools of ourselves.

(Schrodinger, 1944)

5.1 Introduction

The previous two chapters explored descriptive features and aspects of transport processes at different scales and in different contexts. Themes included materials movement associated with mechanical work, common design, feedback processes and transformation. Aided by better scientific instruments, knowledge of how living things interact within the environment and explanations of how materials interact has developed a lot during the last fifty years and this has created the opportunity to reassess the place that transport systems play in the creation of new entities and the way those processes can be theorised. Examining transport in systems at different scales and physical makeup also provides new ways to explore the nature of the world. Conversely, a focus that is more inclusive of material process also offers to reward enquiries that leads to a better understanding of the behaviour and properties of different transport systems. This double articulation offers the chance to develop an understanding of transport systems within a common metaphysical context that can explain why materials move, recombine, and exhibit novel properties. The objective of this chapter is to find new language to meaningfully theorise the properties and capacities of transport systems. The argument I develop in this chapter is informed by the work of the realist philosopher Manuel DeLanda and I use his work to explore transport processes within new materialist thinking about how the world progresses. The description of transport as active and transformational when interacting with material entities resonates well with the metaphysics of Neo-materialism. As a philosophy it engages the immanent properties of material and I combine that with the idea of active transportation in explanations of how entities develop, and this provides a launch point of an ontology for transport. The approach I use to do this is to take the summary information of preceding chapters and examine in neo-materialist terms the ideas and mechanisms that are at play.

Theorising transport systems requires a concomitantly consistent metaphysics of matter and the emergence of novelty in the world. What I mean by this is that consideration of realist transport ontology also requires a realist ontology of the material and social systems within and between which transport takes place. My developing theory of transport affords an ontological commitment to the capacity to affect where there is also a capacity to be affected is part of a realist material and social ontology and hence a change in the subject object relationship. The connection between transport and matter is apparent when considering activity such as a delivery of goods to a supermarket. It is also the case when considering the materiality of social interaction as it is where transport is part of land use modifications such as the clearing of the rainforest in Brazil. At first, I explore these ideas without reference to human systems to firmly identify the nature of transport processes within realist ontology. The focus remains on non-human material interactions to ground emerging commitments to transport ontology before considering how the contents of human minds can theorise transport in a social world.

I speculated in Chapter 4 that transport processes are not inherently responsible for directing change towards some pre-determined end but are part of a probing and exploration process of possible material combination. That is, I am not proposing that there is a universal transport agenda as a primary explanation of the development of structure and complexity. It seems more likely that transport processes that move material entities at many scales, perform a physical role in realising emergent properties that allows immanent tendencies within materials to become actual. This suggests there is a new way to theorise transport as a process within the creation of entities that relies on abstract architecturally similar mechanisms for the resulting dynamic interaction. That is the argument developed in this chapter in a way that there is no recourse to reified generalities and their limited ability to adequately explain the production of novelty. That is, if it is argued that if an object comes into being through the causal mechanism of an ideal form for example that of horseness, 'the production of novelty stops because its development is closed as 'horseness' is determined and fixed.

The previous two chapters describe transport systems at different scales that transport materials within and between entities and use a range of identifiable transport mechanisms with similar structure and functionality to those found in human goods transport systems to do this. While this is interesting to the extent that the transport systems at other scales have similarities, the description of phenomena leaves open the question of whether *apparent similarity* is evidence of mechanisms at different scale and in non-human settings that are actually the result of similar processes or whether it is just a coincidental likeness. To answer this question, the nature of

material flows, and the reasons why they flow is of interest here at a deep theoretical level because almost all material changes over the past four billion years have come about in the absence of human minds. Evidence and explanations of how or if these flow processes have similar structural mechanisms is needed to ground a transport ontology. If there are indeed common causes or architectures for transport, we then have a theoretical basis to undertake an explanation of the metaphysics of transport in human society.

There is a renewed interest more generally about how matter – the genesis of its shape and forms – fits with accounts of how the world is. LeCain (2013) notes the lack of consideration of matter in historical accounts of social development. In more recent times, theorising a potentially materialist world has received less focus than attempts to understanding social development through the analysis of documents, and this did not foster thinking about material influences developing social structure (LeCain, 2013). There is increased interest generally (T. Baker & McGuirk, 2017; Bennet, 2010; LeCain, 2015; Muller, 2015) in the significance of ‘objects, bodies and matter’ with a call for ‘rematerialising geography’ in the areas of feminism, urban, social and cultural, resource and GIS science (Muller, 2015, p. 27) Transport geography fits with this grouping and rethinking socio-material processes in this context gives legitimacy to an exploration of the presuppositions about transport systems within a material world. The centrality to transport demands consideration of material flows and so directed my search for an ontology of transport within materialist philosophies informed by discoveries of material behaviours in chemical and biological research.

5.2 Towards an ontology

My preliminary research investigated factors that generate goods movement and how they are related to a range of economic factors of production as correlated by complex mathematical formulae. To me this is interesting but not informative of any consistent underlying presuppositions or theory about transport and movement. An applied mathematical approach can quantify the outcomes by varying input factors but tells little about how the underlying architecture or the causes of those effects interact, or which ones are significant. The varying conceptions of transport within the wide range of disciplines where transport phenomena are found further blurs any consistent understanding of the foundations for transport study. The lack of consistent presuppositions about transport is only a problem if transport, as a thing, is thought to need a central and consistent meaning in its uses. The challenge for materials transport in human systems revolves around timeframes, the probing of new processes and the how the contents of human minds and material processes are interrelated. Transport in social systems is specifically addressed in the next chapter.

If the word transport is merely a generalised way to refer to many different movement activities, or the bringing together of materials then what is accomplished by those actions are primarily related to those interactions of interest and not transport generally. The richer picture now developing through scientific discovery identifies new ways to understand transport and emergence of entities and so offers a theorising space that supersedes generalised self-referential definitions of transport as being solely about the movement of things. It provides impetus and an invitation to seek out a basis upon which to theorise transport as part of processes leading to the 'evolution of novelty'.

To begin I will briefly describe what I mean by 'Ontology' and how I came to consider the importance of ontology in a transport world manifest as concrete bridges, container roadways and rails., with routes between source and destination that can be explained using an Automobile Association road map. I have been looking for how the underlying systems diagrams of the type that Odum and Swenson say better represents real flow processes apply to goods transport, and thing that realist ontology offers a way to ground the notion that there is an abstract architecture of virtual process that is consistent in the way it acts on materials.

A key requirement of ontological commitment is that it describes the set of entities assumed to exist as reality. It does this by naming the types of entities that a philosopher is committed to assert actually exist (DeLanda, 2002). This short definition immediately raises the need to define what it means for something to be a real entity. Ontology gives a name to what is asserted to exist and commits the philosophic enquiry to that reality supported by the underlying set of entities that are assumed to exist. By committing to a realist ontology I can then argue that the way entities come into existence can be explained in neo-materialist terms. : For an object to be considered real, there must be a plausible material and historical explanation of how the entity came into being, and an expectation that it has an end date as well. (DeLanda, 2002).

Interest in realism and realist ontology has increased since the turn of the century, with wide ranging speculation on how reality fits with our everyday perception and common sense. A realist ontology grants the natural world full autonomy from the human mind – and, as far as the natural world is concerned, is not dependant on the human mind for its existence. (DeLanda, 2002). A defining characteristic of this commitment is the rejection of an anthropocentric view about whether there is a difference between unobservable and observable events. Realist ontologies can also allow for social items such as dollars or laws as these clearly are dependent for their existence on human minds, but not on the contents of those minds. This distinction allows for a realist social ontology where for example an individual can choose not to accept that social laws exist, but that doesn't change the reality of those laws, or the consequences of not abiding by them.

What to accept as real, or how to tell something exists then becomes the question. One interpretation of realist ontology accepts the existence of fully formed objects that credit their 'thingness' to the possession of an essence as the basis for their persistence through time. To be real requires an external immaterial property. The path I take to explore ontology and transport differs in that the standpoint that the processes involved in forming reality are always explainable without recourse to transcendence or essentialism in any form. This requires there to be mechanisms that act upon or act within materials that form transport systems with no recourse to the concept of ideal forms of essences. To do this requires something other than explanations relying on reducing transport systems to reified labels in social conventions, such as the ability 'to satisfy' an appetite for goods.

Accepting as realist ontology allows for living things to have direct knowledge of other things in the world where those things that are real are the result of historical becoming and not approximations of general categories. Realism therefore excludes essentialist ontology that relies on a set of defining characteristics which explain the identity, and relationship, between the general and the particular. The systematic direct interaction between the epistemic and the material aids transport ontology, where the evolving material environment interacts with the formation of life and complexity.

If a non-realist ontological commitment has it that reality exists only in the minds of humans, then that ontology can only assert the existence of mental entities. Those entities can be symbolic and expressed linguistically or exist as ideal models with some commitments of this type accept objects that can be seen as having mind-independent existence. Such an ontology however is ambivalent on the status of entities that can't be directly observed. These include entities such as physical causes and electrons for example fall into this category.

An ontology may also describe and the mode of existence of a thing, i.e. whether it is an object, state or a substance, or a single instance of a kind of thing. Ontologies are also crucial in categorising and relating different things, of understanding the notion of identity between different things for example causation, and the nature of properties and essences. The limits to what ontology may contain is not confined to things thought to actually exist allowing that virtual or fictional existence are also valid topics for ontology. The particular ontological issue in this thesis concerns identifying what kinds of thing exist according to my theory of transport meaning what does this theory or world view commit us to, and what are its 'ontological costs' of such a commitment.

The term 'flat ontology' is used by DeLanda to describe the world as a flow structure where every entity has the same ontological status. A flat ontology rejects the hierarchical relationship between general types and particular instances where each level of the hierarchy has a different ontological category such as genera, species, and organisms. The implications of flat ontology are that living systems of different levels will always respond in the same way to claims the ontology makes regarding all the main commitments and relationships of the ontology. Most importantly it allows assemblages of different types and scales to actively change to become new assemblages. Reality seen in this way can be defined as emerging in the world through the processes of assemblage. For this to be the case in the world, every living thing can be defined by their historically constituted identification of the processes that brought them into being.

The word ontology is also used in computer science to describe the specification of the things in the system being programmed and how they relate to all other things within that field of interest (Staab & Studer, 2009). Here the use of ontology is a way to inform methodology by giving an explicit account of a conceptualisation within a piece of specific software and so describe how different parts of the computerised system are represented and interlinked. It provides a unifying framework for work in the domain of transport networks for use by transport theoreticians and (via resultant methodology) policy practitioners and so the use of 'ontology' in this way meets the specific need of programming through the provision of a system framework only.

In contrast, a commitment to a naturalised transport ontology considers both the movement and transformation of things that are transported. It is more than a classification of information flows. The scope of transportation processes being addressed here needs elements of both scientific ontology and philosophical ontology to satisfactorily explain commitment to the emergence and existence of entities. Where I posit that transport and related entities exist or are presupposed to exist I am engaging in scientific ontology because of the inclusion of things I regard as significant and meaningful to the wide range of disciplines in which transport is found. In biological systems I am also including the philosophical aspect of ontology concerning what it is to exist or how to exist with all the things that are or have something in common.

Fulbrook (2009) notes that the core ontological ideas about social reality have existed in Continental philosophy and social theory since the 1970's and are widely accepted everywhere except for economic theory and replace the ontology that formalist methods implicitly assume (Fulbrook, 2009). This exception is significant to transport as economic thought, methods and theories underpin supply chain and logistics development that in turn support globalised, deterritorialised markets. Changes to orthodox economic beliefs is slow with those like Lawson who challenge

axioms and economic hegemony find that rather than confront the issues it is 'probably strategically the wisest is just to ignore' challenges to the status quo (2009, p. 78).

It is the of potential of a new way of thinking about material activity that leads Lane to suggest that by excluding this way of thinking no one has been specifically looking at how self-sustaining processes develop, and this omission has led to 'a black hole at the heart of biology' (Lane 2015, p3). Effectively what he claims is that ontology of non-Darwinian evolution excludes the need to find ways to satisfy a 'how to' explanation of emergent processes. Torday and Miller sum up the new areas of focus when they say 'evolutionary development can be reframed as separate from Darwinian selection and is better understood as the product of cognitive cells solving cellular problems...through intense communication' (Torday & Miller, 2016, p. 345). Materials, social systems, transport, and communication have a place in new perspectives like this.

It is time to move past the ontology of modernist philosophy, and of constructivist theories. A focus on linguistics, on human exemptionalism and on transcendental mind-based world views provide an insufficient explanation of the origin, nature, and influence of transport in evolutionary systems that include current human systems. In summary, social constructivist theories and analytical methodologies marginalise the capacity to affect and the capacity to be affected found in all heterogenous assemblages. Blotack-attached labels signifying the 'what is' of transport systems can be replaced with meaning derived through the interacting of processes. Any attempt to isolate the natural world from the process of knowledge creation can only act as a barrier to understanding a naturalised transport philosophy. The recent interest in neo-materialism has yet to come to the attention of theorists interested in the emergence of complex transport systems. There is still a propensity to theorise emergence in terms of word meaning ontology or at an atomistic basis with reified generalities such as 'the market' and 'individual choice' and little else in between. To summarise; transport is open to theorising in neo-materialist terms, guided by realist ontology. An ontology is realist where things in the world are fully autonomous and exist and relate without the need of a human mind to add meaning.

In the preceding chapters I have covered how individual topics of study do not form a joined-up view of processes that contain a transport component. My aim now is to situate transport theory within an ontology expressed in neo-materialist terms and realist philosophy and identify and clearly describe what the most fundamental and basic entities are that are studied across all science. Transport ontology accepts the directional flow of energy in work that always strives to maximise entropy. A steam engine demonstrates how a commitment to directionality is consistent with the Second law of thermodynamics where heat flow is always dissipated at the maximum rate,

otherwise the engine would run erratically. This observable phenomenon, which can also be observed in cooling custard, can be described in a way that gives a non-human connotation of 'selects' to directionality of energy flow. The ontological commitment to structure in the world is demonstrated by low entropy entities that exist in high entropy flow environments that stay far from equilibrium by selecting energy flow pathways in structures that maximises entropy production. The ontological importance is that heat flow is maximised and directional in every case and so supports structures that persist away from equilibrium producing high quality energy to power orthogonal, epistemic movement counter to dissipative gradients. The implication is that the directionality and directness towards a final state of maximum entropy provides a mechanism that powers more complex movements. All living systems therefore have selection architecture capacity that searches for steeper new gradients from which to draw more energy.

From a Deleuzian perspective the development of evolutionary systems are repetitions of 'blind metal probing'. The reference here to metal reflects the capacity of chemical metals to bind and bond to form new substances. The persistent exploration of gradient and attraction can lead to novelty or, as the evolutionary record also shows, to the death of individual species. This combined with reinforcement processes that create power and resilience of a system (as defined by H.T Odum) means that at any one time there can be developments that are always of a contingent nature. This suggests that to understand the final form of entities the 'unseen' but real processes that bring about change must be understood. Transport gradients within intensive processes offers a direction for this enquiry.

The abstract architecture behind similitude is separate to the entity as the actual mechanisms of emergence may differ materially. Mathematical models overlap with the space of possible solutions giving them the ability to simulate the mechanism independent components can be used to partially model real systems as they can mimic behaviour of the processes they model though their underlying behavioural isomorphism (Delanda, 2011).

5.3 Introduction to neo materialism

Neo-materialism, has as its focus the dynamic inclusion of all living things, humans in particular, within an active material environment from which they both originate and interact. It offers an alternative to Descartes' dualistic world view, with its singular commitment the idealism of thought as the driver of creative process and considering matter as dead inert matter that is acted upon by ethereal forces. Materialism claims that physical matter is the only fundamental reality in a world that is considered to be a static and isolated environment and view everything as ultimately physical

including the workings of the mind and consciousness considered biproducts of material processes. In taking this approach Materialist philosophies tend to be associated with reductionism in a way that commits the material world to be regarded as a static place to be inspected. New materialist develops upon the philosophy of materialism by attributing a new and active role to matter in the evolutionary development of the earth. Neo-materialism in contrast to materialism animates material interactions and focusses on flows of matter creating access to where as humans we can have 'an appreciation of just what it means to exist as a material individual with biological needs yet inhabiting a world of natural and artificial objects'. This way of thinking about the world shows a clear distinction between materials that have only physical properties such as length breadth and mass, and an acceptance that the interactions between materials that are made possible through their innate properties and manifest at times of high intensive difference and most observably when systems are far from equilibrium. Interaction between materials within material systems suggests a commitment to a world where real events produce other real events, and this helps extend the concept of materials having the capacity to affect and to be affected without recourse to reductionism while at the same time allowing analysis of the active processes.

By expanding the idea of events that cause other events DeLanda has derived a form of material assemblage thinking from the materialist ideas mainly found in the work of Deleuze and Guattari. DeLanda's realist metaphysical account of new materialism is accessible in his theorising and made 'work ready' (compared to the prosaic writings of Deleuze and Guattari) as a philosophical argument in his book *Assemblage Theory* (DeLanda, 2016). DeLanda calls this work a reconstruction of the ideas in Deleuze's texts (DeLanda, 2002). In that book he develops their ontology by adapting and seeking out alternative ways of describing the identity of fully formed objects without reference to or need of essences. DeLanda's alternative approach is to develop theories that account for material and energetic dynamical processes, and this attracted me to his work as it offers the potential to develop the metaphysical aspects of the work of Odum, Swenson and Lane and apply it to transportation. His work includes defending a materiality in the makeup and interactions found in social systems and so provides explanatory connections with earlier cultural materialism theories. In my search for active processes with commitments to transport ontology included his exploration of the realm of intensive science and virtual philosophy (DeLanda, 2002) and the groundwork he sets out for a new philosophy of society (DeLanda, 2006). DeLanda's interests in new materialist thinking are expansive so I limit my interest to areas specific to transport and that is broadly covered by his exploration of the nature of assemblages, territorial coverage and the extent of coding and regulation found in healthy systems.

The philosophical extension of materialism to new or neo-materialism is not to be confused with post materialist thinking with its focus is on a values system and its rejection of consumerism. Neo-materialism instead explores and develops thinking about the properties of matter to include them in actively shaping the environment of the earth. It focusses on the expression of the innate qualities of matter and how they can reveal a much more 'alive' physical world that can participate in an explanation the evolution of the world. The importance of a realist ontology is seen here to account for what there is in the world that developed without the presence of human minds, and so is philosophically diametrically opposed to any explanation that relies on non-material ideal forms to explain things in the world. What Neo-materialism offers is a viable alternative through developing a new understanding of the active mechanisms that create and assemble entities through historically traceable material processes that explain the genesis of things that are real. As established in Chapter 4 the discovery of active transport processes in the earliest development of living systems both fits with and provides evidence of the value of this type of thinking.

Adopting a realist view of the world also requires a commitment to explain how real mechanisms interact – even when those mechanisms may not be directly observable elusive or hard to describe in Newtonian mechanical or Neo- Darwinian genetic terms. The specific feature of new materialism is the way assemblage thinking offers new ways to explain transport processes that excludes the need to think of whole entities as being seamless totalities. A key definition in this realist approach relies on an explanation of how the reality of entities is established. DeLanda's (2012) remedy for this is to argue that something is real if the historic process that created the entity can be identified. This is very different to the idea that there are timeless categories of things and relies on the existence of real things that can interact.

In this account, entities are defined by morphogenic processes, where materials go through change based on the notion of 'the different' to drive dynamical process (DeLanda, 2002). This is an inherently dynamic account that explains why individual entities have topological resemblance to each other that is not based upon a likeness to an ideal form, or to some sort of common non-material essence of say 'tiger hood'. It is process most commonly brought about by an intensive difference such as pressure, concentration and speed that act on matter and so account of the genesis of the material form of plants and animals and the form of inorganic crystals (DeLanda, 2002). A morphogenic account does not then rely on transcendent factors but on resources which are immanent to the material world (2002. p2).

The importance of material interaction as a central evolutionary concept relies on the commitment to a world that exists in itself, with the proviso that what humans identify as being 'in the world'

cannot be taken as complete knowledge only on its face value but must always be explainable and analysable through its historical production process to get as close to the thing itself in our understanding. An explanatory ontology such as this doesn't require deferment to a 'black box' process where inputs and outputs are accepted without need of a detailed account of the internal transformation process. The technical and scientific situation that not all transformation processes are currently fully explainable through the lack of a complete explanation of the historical processes that produce the outputs, is not a fault of realist ontology, but offers exciting prospects that future projects will develop and explore them. By approaching the role of transport this way requires the commitment that the explanation is understood to exist and to accept a commitment the existence of virtual abstract diagrams of production. The challenge for the biological and physical sciences and neo-materialist philosophy becomes how to search in the right places to uncover the mechanisms that lead to the way entities are formed. This challenge also extends to the social sciences and to geography and economics in particular to consider how the abstract architecture of material processes integrates with social material processes. An explanatory methodology used in this way goes beyond a static analysis and extends to making a good description of what is under study, as an explanation that includes the detailed workings of mechanisms that may not be directly observable but are real determinates of how materials are expressed. Transportation processes are ripe for this type of analysis.

5.4 Intensities

The distinction between extensive and intense systems, is not widely thought about by philosophers (DeLanda, 2005) and yet it is here the role of transport is significant in processes of change. The importance of difference in morphogenetic processes is a central part understanding and subsequent epistemological possibilities that intensive difference has to theories about the creation of novelty. In this space the immanent properties of materials are active in the production of contingent structures. Intensive processes worked on by abstract machines that act to cancel difference and then reveal novelty that is expressed in extensive terms – things that can be measured or weighed or counted. This is the case for geologic, organic, and social materials (such as linguistic materials) and is most evident at points of phase transition.

As described in the literature review, most transport research start by identifying and measuring the end point of extensive difference activity. That is, the obvious or measurable properties of a whole are the centre of attention and the basis of what scientific and social 'graphy' worlds act upon. Measurements are of tonnes per km, distance between centres and speed of delivery. Transport spaces are considered in terms such as the volume of a shipping container or the output capacity of

an engine. Where spaces are bounded by natural barriers such as skin on our bodies, or by extensive boundaries such as the walls of a city or the border between countries, the metrics of how they operate and is only a partial description of the system. There is much more to know about the performance properties of which they are indirectly representative that include the unseen intensive properties that formed and maintain those entities.

Systems change state at certain intensities as spaces of intensive difference also exist, and their definable possibility spaces have edges to these zones where critical points are manifest as abrupt transitions that change the state for inhabitants of that zone (DeLanda, 2005). A merging of these intensities does not add their values together but drives a movement towards or activates a transportation process that results in an average value of the two systems. Where intensity increases to critical points the system experiences an abrupt transition, a change of state, for inhabitants of that zone. An example of this in nature is where the change in the rate of flow in a river results in the transition from laminar to turbulent flow. DeLanda says that a bounded system can have zones that are 'marked by critical points of temperature, pressure, gravity, density, tension' and speed (DeLanda, 2005, p. 80). A Neo-materialist philosophic language offers a language to describe how these intensive processes bring about the genesis of form, such as a plant, or an inorganic crystal. It is a process where far from steady state entities are in a region of intensity and this reveals different virtual attractors that drive productive differences.

The new or final shape and exterior features do not reveal the shape of intensive processes. They are the extensive result of the internal intensive differences that brought them about. This causality mechanism allows for a chain of events, such as the Krebs cycle where a chain of events is driven by gradients and attractions. It is the production of one event from another, and through objective synthesis that new entities are brought into existence (DeLanda, 2002).

For example, a truck moving goods can be described extensively by what it weighs, how long it is, and how fast it is going. These measurements however cannot be modelled to show much about how the journey came to be or what it is that caused the truck to look like it does, or how it operates the way it does. To better understand how the metal clad monster operates requires a knowledge of the intensive differences that brought it into being. The architecture of those intensive differences explains the capacity to go uphill, the temperature gradient of the cooling systems, air pressure in the tyres, the potential energy in the fuel, combustion pressures compared to atmospheric, tensions between atoms holding the whole entity together.

The production of diverse extensive spaces through intensive processes (in intensive spaces) is a key feature of Deleuze ontology (DeLanda, 2005), and cornerstone for a neo-materialist metaphysics. Within any whole entity are assemblages relying on intensive differences for their expressivity. The importance of this phenomena for Deleuze is that it is as close to the noumenon the thing itself, as we can get. He says “everything which happens and everything which appears is correlated with orders of differences: differences of level, temperature, pressure, tension, potential, difference of intensity” (Deleuze, 1994, p. 222). I used the differences in that quote to describe the intensive differences that appear above as a goods truck coming down the road.

Materials have properties that are always real but not always actual. These properties can be listed and come about through the interactions of the components of materials that result in specific properties. DeLanda describes the relation like this: ‘The properties of a whole emerge from interactions between its component parts. In those interactions the parts must exercise their capacities’ (DeLanda, 2011, p. 4). This is important for transport as the interactions require movement in space to interact.

The exercise of the capacity to affect depends on the existence of other real entities that have the capacity to be affected. The interaction requires a material connection which is offered by transport systems in many cases. Connection via social materials is addressed in Chapter 6. While properties are finite, the extent of capacities to affect are found out through the actual interaction of entities and depend on capacities to be affected. This concept is central to an epistemic understanding of transport. The movement and combination of material with different properties creates an open future of opportunity to create new entities.

The sciences concerned with emergence show material interactions exhibit evidence of tendencies. In realist philosophy these tendencies are real, but not always actual. They manifest within possibility space as things like flow patterns and at critical points tendencies become discontinuous such as when water flows are uniform, turbulent, or periodic.

Transport has the capacity to bring together very different materials at different times and in no particular order. The use of simulation in systems with a transport activity can be to vary the parameters of virtual entities and see what properties, capacities and tendencies emerge from the change. This complements the role of mathematics in working out the structure of possibility spaces (DeLanda, 2011).

Realist ontology opens up the possibility of goods transport phenomena being part of the evolution of populations on which natural selection can operate. Swenson provides a starting place to explore

physical selection processes that include transport, and how as a system function it will select the path or assembly of paths out of available paths that minimises potential or maximises the entropy at the fastest rate given the constraints (Swenson, 2010). Transport ontology commits to higher laws that control other laws, and in particular the pre-eminence of laws that govern thermodynamic behaviours at every scale. Swenson places the mechanisms of maximum entropy production in that group of higher, or ordering laws so committing to a persistent force responsible for the directionality of nature that can be called 'to strive'.

There are three intensive and expressive aspects of 'vibrant' matter that need to be considered in transport systems. They are intensive social communication, the storm of information and the visceral interaction with materiality (Bennet, 2010). Of course, changes to transport systems without changes to the material processes within which those transport systems form assemblages would not work.

When we give legitimacy to material expressivity and the transport systems that form part of the emergence of form and complexity, we extend the mechanisms of creative acts to the emergence of world itself. Accepting the legitimacy of material expressivity opens the way for ontological commitment to an innately creative environment, where new entities can emerge without human intervention. The expressivity of hurricanes is an example of an intensive heat engine, the size and life of which is determined by heat gradients and the organisation of heat dissipation within the hurricane. The greater the heat gradient, the more expressive the hurricane. The changing of intensities leads to questions about what becomes actual in the world when human intervention alters relations within that innately creative environment. This is a central problem when intervention is in the form of transportation.

. What is being discovered needs to be synthesised, and Harris (Harris, 2001) gives some direction on how to proceed here by saying that the facts found need significant theories to create relevance, just as theories need facts to create scientific credibility. Finding theories that satisfy and inform an ontology of transport is a particularly tricky job as any transport system has technical, scientific, and social (communicative at least) components that must be accounted for in any rationale.

A logically deduced or physics based determination of systems behaviour is not the path I take here as I am not attempting to find general laws derived from ideal phenomena that are created mathematically, or that can be deduced from idealised models (DeLanda, 2016). Of more relevance are the metaphysics of sciences that cope with matter transformation and the production of novelty (chemistry, biology etc.), as they deal with how materials interact and express behaviours within the

confines of 'environment Earth'. I take as a starting point that the study of these sorts of systems should not focus on determining specific outcomes, such as trying to predict actual braiding patterns in rivers, as living systems are faced with extensive possibilities of interactions with different capacities to be affected and so have far less predictable outcomes, if they are predictable at all. As with changes to channels in braided rivers, their study needs to focus on the conditions that prevail when materials interact, and on a search for the presence of 'systems architecture', the understanding of which can indicate the types of outcomes to expect. Transport is found in this mix of systems that are more than causally mechanical or equilibrium seeking, and so understanding the production of matter informs transport theory, and vice versa. In 1748 a billiard ball model was the standard way of explaining cause and effect in nature, where atomisation and reducibility of everything to minute particles offered the best way to explain the impulsive workings of the world, where nothing is mysterious or hidden (Hill, 2003). Energetic systems such as braided rivers are anything but the felt lined plain of a billiard table. Now it is time to examine the hidden, the non-atomised wholes that are not non-reducible to the sum of their parts.

5.5 A metaphysics for material movement

A claim of realist philosophy is that the earth exists independently of the human mind and earlier chapters discuss transport systems that developed high levels of complexity and communication before there were such things as human minds. This is a significant point of departure when considering transport as a derived demand or through an appeal to ideal forms or agency in requiring likeness to the essence of a certain thing. As an alternative the similarity in mechanisms identified suggest that while the development of entities has an element of blind probing and chance, it is also guided by a nomological processes of seeking difference through gradient and connections via facilitated attraction. The evidence that transport processes are entangled in the first cellular activity in hydrothermal vents in this type of 'blind probing' indicates the presence of a type of natural causality, where one event can be explained as objectively producing another event independently of the existence of minds. Significantly this type of causality does not need a witness or a motive such as maximum power production. What can be said about transport here is that there is evidence of its connective agency in causality, found in different events and scales. How this happens reduces ontological commitments away from the anthropogenic recourse to forms or essences, and towards commitments about controls and tendencies within the environment where materials act upon each other. If structures assemble themselves with transport processes only through material actions and interaction, then what is it we can say about these interactions? What

differentiates them from alternative claims that material is inert and plays no active role in structuring the living world?

A way forward is to recognise that the world is an evolutionary 'population of one' and as an entity that expresses novelty through interaction, it requires more than a Darwinian selection process between competing populations to explain the need for transport and form. As a single and self-supporting structure the earth is somehow in the order-producing business (Swenson, 2000, p. 317). Lane states the natural production function even more strongly and wonders if the expression of novelty makes life a by-product, or side reaction to the main energy releasing reactions of the world that have effectively maximised entropy production for the last four billion years. Over that time the process that increases the output of production has increased a million times, where the original input to the production of 1 gram of biomass probably creating 40 tonnes of waste when doing so (Lane, 2015b). A focus on material, energy and waste disposal creates a very different starting point to the Cartesian dualist view where man is defined as separate from the dead physical world and the view that knowledge can only be derived from reason and method. The material causality argued for here is antithetical to an epistemology of the atomistic individualism of the self, or a methodology dependent upon mathematical formalistic tools to model abstractions of the world. What I focus on now is the workings of a visceral material world that organises and develops without human direction and manifests transport processes to this end when and where ever it can. Of course, there are now the material institutions of human society interacting with those same materials and building complexity. They also need to be considered.

Darwin looked at the world and explained what he saw as material changes that resulted through the selection of entities that adapted to and survived well within the constraints and opportunities of their environment. At the time he was writing there were also significant geological discoveries suggesting that other changes had occurred over a long period of time – much longer than the received understanding of a 6000 years' time frame. 'Prehistory' if considered in this way includes billions of years of material change that opens up for consideration the exciting prospect of a comprehensive, non-human centric process of evolution on a huge physical and time scale. Pre-human history in historical accounts is not well linked to the historical account of social development (LeCain, 2015) and so accounts of this period don't address in detail the influence that material processes have on emergent or proto social processes. Lane's account of the first cell development suggests that during prehistory, very complex living systems developed transport processes, and this point alone invites an exploration of why the material active prehistory matters for a better understanding of transport processes. Addressing transport systems as material

activated processes that shape social processes takes transport theory in a very different direction to the modernist view that man is outside nature and culture and that human intellect is non-material. Neo-materialist thinking offers a way to do this as it is the antithesis to the social construction of meaning. The operations of pre-human transportation in an active material world suggests human systems are borne out of the same evolutionary processes, and this is consistent with LeCain's view that 'human culture must be understood and analysed as a part and product of the material world, not its antithesis' (LeCain, 2015).

The metaphysics of neo-materialism requires a change to the presuppositions about how we understand the production of new entities with emergent properties that are not found or predictable, from an examination of the component parts. I have established that the production of novelty includes the transport of matter. If there is a defensible metaphysics for this, then there is also a defined starting point for addressing a theory of transport as it applies to human systems where the production of novelty also occurs. Approaching social transport systems like this allows investigation of transport that is not solely centred on human action. It shifts the focus away from human beings as separate architects of culture and positions them as participants in evolving and emerging culture. It recognises all material entities as inhabitants of the world where humans are just one of many forms of novelty generated in a dynamic and lively space of interactions. At the extreme the paradigm of production changes from where transport moves goods because it is required as a derived demand of other processes, to an understanding that things come into being through the transport of matter.

Concepts of emergence differ between physics and chemistry and in the early 20th century could not be explained. The interactions of interest in physics does not produce novelty and the effects can be explained by reducing them to deductions from laws or general principles (Delanda, 2011).

Attempts to explain emergence include recourse to vitalism or life force or to simply describe emergence as unexplainable (2011, p2). Science has found ways to elucidate mechanisms that produce a given effect, which changes the epistemological status of emergence but left the ontological status unchanged (2011, p3).

A realist philosophy gives entities, resulting from emergence, an ontological status of objective irreducibility. It has properties that are more than the sum of its parts. The emergent properties can be explained as an effect of causal reactions between its component parts. When looking at early cell development we can historically explain what initiated the process and identify what sustained interactions between the parts. This historical view includes identifying transport systems in the process of creating reality.

A useful outcome of more complete transport theory could include an exploration of the common aspects of DeLanda's virtual architecture and simulation models that explore patterns of attraction. Examples of how simulation models are currently used can be found in the work of White et al. (White, Engelen, & Uljee, 2015) for planning applications that rely on modelling cities and regions as complex systems, and by Allen (Allen, 1997) who considers cities and regions as complex systems and considers ways to model their behaviour. In considering emerging theory for the modelling of complex systems White et al. recognises that realism is required of the applications for planning and policy. The writers suggest a suite of overlapping models to cover generality, realism and a precise account while being applicable to any city or region (2015, p235). Several Cellular Automation based, and dynamic central place models are considered by White et al. The question is then asked: But where is the theory' (2015, p.246). For the rest of this chapter I put forward an argument that, at least for transport, the aspects of the theory reside in epistemology developed through new materialist thinking that is based on my transport ontology. The theory that most closely fits with the description of transport processes and how they can be explained is a development of Deleuze work as theorised and made more practical by Manuel DeLanda. He defends a realist philosophy where the immanent properties of materials are expressed through structure generating abstract architecture (DeLanda, 2016).

Ontology acts as a drafting gate of all possible epistemological accounts of the emergence of life and complexity by allowing the inclusion or exclusion of things that are recognised or identified by developing theories. An impoverished ontology, or one not based on plausible presuppositions allows the generation of spurious knowledge to go unnoticed and to gain traction while having no basis in reality. Conversely, facts need theories to create relevance just as the theories need facts

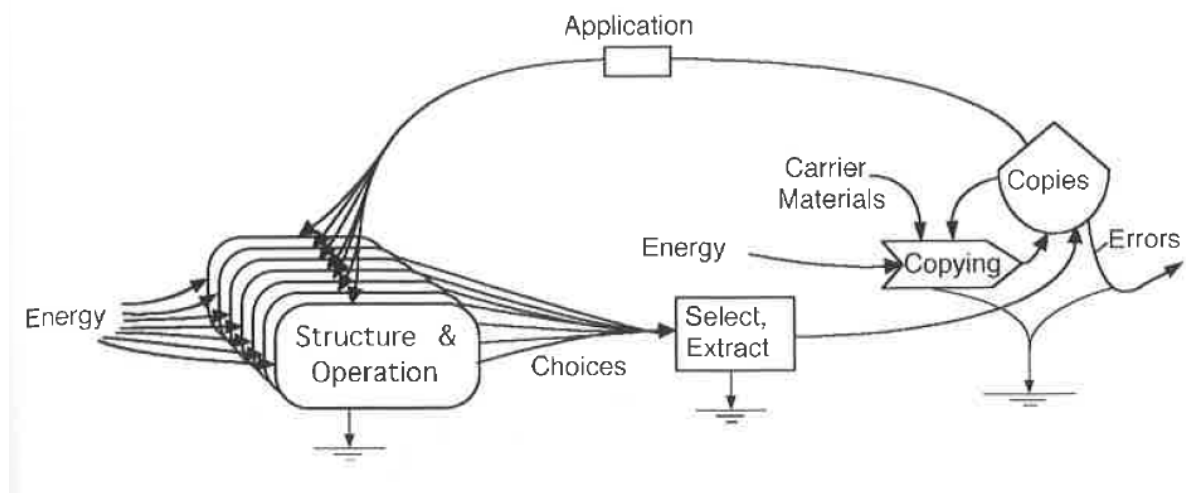


FIGURE 34 CYCLE OF INFORMATION AND OPERATIONAL TESTING

SOURCE: (ODUM, 2007, P227)

(Harris, 2001) and this developmental process has the characteristics of a self-reinforcing system such as shown in Figure 34. I include this feedback diagram as it describes the process of ontological refinement. Here Odum shows how continual processing is needed to select choices, make copies and feed that information back to the systems structure and operations to maintain integrity and continuously make better informed choices and reduce the possibility of errors (Howard Thomas Odum, 2007, pp. 226-227). The model also describes the methodology I used to come to this point of deciding to apply an ontology to the understanding of transport systems. A naturalised transport ontology rejects seamless totalities such as ‘the market’ or ‘society in general’, as such entities do not exist as abstract totalities.

In Chapter two I considered Swenson’s model of entropy flow and structure creation. Here again (Figure 35) I show his diagram of an ontology of a thermodynamic system and then extend my description of it to encompass a more generalised ontology of emergence.

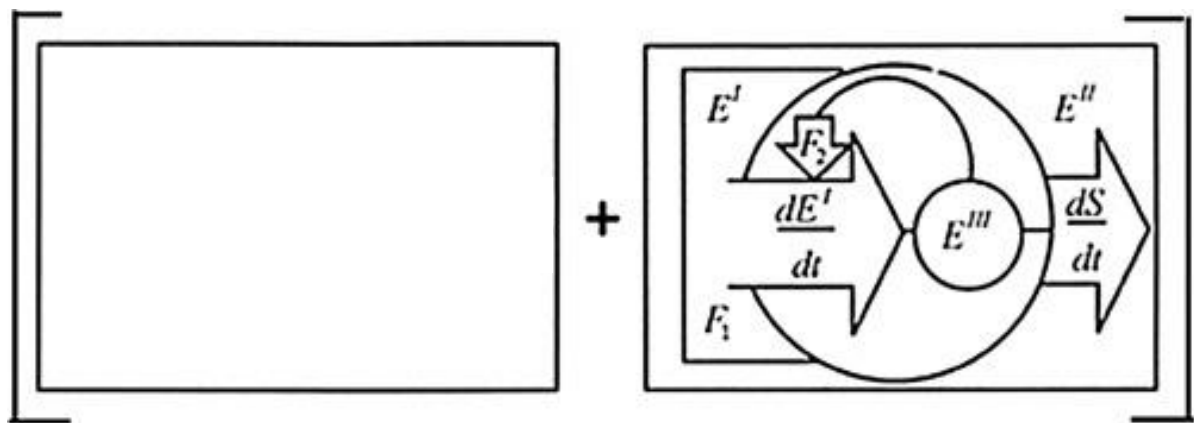


FIGURE 35 ONTOLOGY OF THERMODYNAMIC SYSTEM

SOURCE: (R SWENSON, 2010)

The rectangle on the left represents the conservation of energy, and is linked to the right side that includes a process diagram with circular relations identifying flows. In this representation Swenson develops upon Odum’s energy quality intensifying autocatalytic production process by including more detail about what happens in feedback systems in a real world self organising system situated within an environment and the laws governing their distribution (Swenson, 2010). Swenson’s calls the combined representation the minimum ontology of thermodynamics. His diagram is a restatement of the first and second laws of thermodynamics, in a way that the individual restatements must always be made as the ‘non Cartesian conjunction’ of the two laws (van de Vijver, Salthe, & Delpos, 1998). In the above model, the left hand side shows that which is invariant as stated in the first law and is conserved and is neither ‘self or other’ (1998, p. 164). Swenson argues that our experience of self is only in relation to that which we are not and so on the right

side of the diagram is shown the self-other circularity constituted relationship in the directional flow environment of the second law of thermodynamics. Of this Swenson says:

The non-Cartesian conjunction provides the basis for understanding the commensurability between physics, psychology, and biology where it becomes possible to subsume what is right about closed-circle theory and evolutionary epistemology, while getting rid of the Cartesian ghost and the resulting degenerative problem shift to give a principled account of the emergence and evolution of meaning and intentionality or the epistemic dimension

(Swenson, 1998, p. 164)

The right-hand side shows schematically how epistemic agents can be seen to arise out of an 'autocatakinetic, self-organising and spontaneously ordered system'. As such, they are flow structures that pull resources into themselves through motion or flux to maintain their identities. Swenson summaries this as 'invariance at one level, the form of the thing, is constituted by change or motion at the component level' (Swenson, 1998).

Odum's theorises about the 'transformity' of energy quality from one level to another and this is accounted for in Swenson's model. The 'transformity' mechanism in Odum's work that accounts for power accumulation in systems relies on large flows of energy at one scale to produce a small amount of energy at the next scale up, and so on and so forth. The success of the process relies on some of the previously transformed energy at the next scale up being fed back to a lower level as a controlling mechanism for input energy to the system at that level. It is a process he referred to as 'tripartite altruism' as, in general terms a third of the energy flow maintains the entity at the scale of enquiry; a third is fed back to entities at a lower scale and a third is fed forward and provides input for entities at the next level. Every stage in this process relies on transportation processes as gradients of difference, the physical movement of matter and the transfer within that matter of 'information about' the process and environment. Swenson calls this general process autocatakinetic as it maintains its 'self' through a set of nonlinear circularly causal relations and can involve catalytic causality where chemical interactions result in an effect, but the chemical is not changed. It is a model that describes matter in an interactive process of change.

As an architect who is also interested in the ultimate nature of matter and space Alexander (1977) also rejects the core assumptions of Bacon and Descartes that matter is inert and mechanical in character. He sums up their views of the material world by saying 'you pretend it is inert to understand how it works'. It seems that the concept of a 'black box' in this context are the

processes not ontologically supported by the current theories of the time. The challenge to find how entities actually manifest themselves through those black box type processes led Alexander to consider the structure of wholeness with the observation that 'what grows and unfolds' does so 'as a natural consequence of what it is, because it literally grows out of wholeness – structure in space – a structure of symmetries that exist in the way that a given portion of space is differentiated. Immediately the similarities of this description have with Swenson's ontology are apparent. The idea of wholeness as a structure in space as a real structure also has parallels with Deleuze' concept of a plane of immanence, from which things in the world emerge through a process of segmentation where the discrete components are entities with boundaries that play an expressive role in the functional nature of matter. Alexander describes wholeness as 'nearly a substance' (1980) and goes on to he describe the limitations of physics where it identifies the behaviour of electrons, photons, as dependent upon the wholeness defined by the apparatus and so we do not have an adequate way of depicting what wholeness is. DeLanda offers a solution to this with the concept of an N universe. For the description given by Alexander, the wholeness of the apparatus would be an N+1 dimension. What DeLanda teases out of Deleuzian thinking is that there are types of advanced maths that describe and so approximate an N world. That is, where the thing itself describes its totality without the need to reference an N+1 set of coordinates. Such a non-Cartesian view of the world can flow from Alexanders wholeness as nearly a thing, but a more complete, and more robust explanation is possible using DeLanda's theories of materialism. Here, territorialisation and those things that can be materially traced via the virtual, and mechanism independent processes to singularities, progressively broken symmetries come from a total possibility space that he labels the plane of immanence. The ideas now being developed in new materialist thinking are consistent with those of Alexander who said 'Of course, if this hidden structure of symmetries, latent in space, guides and shapes events in a foreseeable way, then it will be quite natural to say that the unfolding of the system is guided by wholeness, because this will be a mathematical consequence of the system of structures' (1977). This description is close to the metaphysics of neo materialist terms and the challenge here, and that leads to how it can be applied to transport within the new ontology.

Swenson's representation of the combined conjunction of an undifferentiated space combined with an autocatakinetic process of extension can also be seen as a diagram of the ontology of emergent systems in Deleuzian and DeLandian terms and consistent with the descriptions given by Alexander. Swenson calls the left side the conservation of energy but with properties that include large and comprehensive capacity to interact with commensurate physical, psychological, and biological

expressivity. Swenson description of this space resonates with the concept of the plane of immanence, an unsegmented open opportunity space of virtuality.

Swenson calls it an order producing self-driven process where energy flow produces an amount of high entropy material. The model has nonlinear feedback systems that act on input flows. The right-hand side contains an ontology for the architecture of a mechanism independent virtual machine for the process of segmentation where a division of time space of the virtual. Combined, the parts of the model offer the basis of territorialisation and deterritorialisation as theorised by Deleuze. A virtual space, where segmentation, or components assemble and disassemble the real and the virtual. Seen in this way there is an argument for, embedding the laws of thermodynamics within the richer theoretical space of emergence and by doing this provide a firmer basis for a language that describes a realist transport ontology

An epistemological explanation open from the diagram in Figure 35 Ontology of thermodynamic system, is that the laws of thermodynamics can be described as highly segmented, highly territorialised mathematical interpretations of *aspects* of processes of material creation and order production. The meaning taken from this adds weight to Swenson's criticism of the second law of thermodynamics as being a law of disorder. Consistent across all these attempts to theorise order creation is that processes of emergence are found to happen at the first opportunity all the time 'as expressed in the fecundity principle' (Swenson, 1997a) and the overriding lawfulness is a principle of order production. The implications for transport are its necessary function of getting materials close enough together for capacities of immanent properties interact.

5.6 An ontology of transport

Motion and transformation take place in both quality and quantity – in the very substance of things.

Mulla Sadra (ca.1571-1641), Persian philosopher

My purpose here is to describe the ontological commitment forming in this research, and the commitment to the kind of entities that exist within a naturalised theory of transport. This section describes my transport ontology and commitment to theories of transport systems. My commitment to the entities and processes underlying metaphysics from which the transport theories described in this thesis have been developed. There is a sameness of ontology across all living systems at least with respect to the concept of transport. The ontological schema pertaining

to transport, that is, its commitments, and the types of relationships it holds exists between these items, at one level maps onto other levels.

Firstly, there is an ontological commitment to selection processes that arise through the mechanisms of dissipative processes of energy flows. Dissipative systems select the most direct path available to a state of maximum entropy. One example is the observable and nomological way that energy flows within systems always take the quickest or shortest path toward a high entropy state in river systems. Where multiple channels exist such as in a braided river system, water flow will always select the combination of channels that maximise the overall flow within the channel. Should a bulldozer, for example, close off a flowing channel, the system immediately optimises flows in other channels and this demonstrates a physical natural selection process constantly at play in all similar process at all scale.

Swenson's identification that entropy production always selects the shortest path within the constraints of a system offers a nomothetic basis for the selectivity of thermal gradients in all processes and for all materials and mechanisms at different scales. This allows for material subject to transport processes in thermal gradients to select for and get close enough to assemble structures that have different and new properties to their component parts

The neo-materialist philosophy therefore requires a commitment to the occurrence of active transport in natural systems, that moves materials to far from equilibrium states. Active transport processes are powered by sources of low entropy high quality energy for processes that 'climb' gradients and so move interacting matter away from equilibrium. Active transport as a process gains its energy source from the assemblage activities of complex structures that are themselves selected for as energy flows dissipate through their material systems.

There is also a required commitment to processes that transport matter-energy in intensive environments that enable the expression of the immanent properties of those materials. It commits to the reality of materials with immanent properties that are expressed as things in the world. Those things have extensive properties such as length, weight, mass etc, and those entities come about through intensive interactions of matter through forces such as heat, pressures, and chemical gradients. As gradients generate the moving parts of large wholes (DeLanda, 2011, p.9), intensive differences result in the formation of novel extensive expression of new entities. What is important is that the extensive properties of entities are different to an understanding of the intensive processes that produced them. If an alternative view is taken where materials are considered inert in such an analysis, then the production of novelty cannot be fully understood with a neo-

materialist ontology and can only be understood through an appeal to non-material entities such as ideal forms, or essences. The expression of immanent properties follows from the capacity of matter to affect and to be affected.

A commitment to material selection processes allows a formative role for transport in the active material probing of possibility space. The ontological commitment here is that a possibility space is a material thing, within which attractions and gradients are explored. Bossel, for example, describes a space that is like a braided river as similar to the concept of possibility space, where the flow can take one or many channels, but is confined within physical limits as set by the banks of the river (Bossel, 1998). Inherent in this is that any one flow solution does not rule out the existence of any others that could exist between the banks including channels that could be there but do not exist at present. While not all river channels are used, the dry channels remain as potential flows and are still instrumental in the overall design and flow within the riverbed. Within the riverbanks there is a real set of possible flow patterns while at any one time only one set is actual. This leads me to consider that the 'how' of path selection is different to the 'why' and the metaphysics of transport theory suffers from the less than clear expression of the difference that leads to a less than full answer to the question.

The idea that a braided river has a set of real flow patterns that may never become actual is a concept also found in Deleuzian philosophy, where the virtual possibilities are real, but in this case only some flow channels are virtual and actual. In this philosophy things that are actual are considered as an 'event' and not a state, indicating the processual nature of the world considered with Deleuzian ontology. In the case of a braided river the actual channel patterns emerge through interactions of variable and sometimes pulsing flow rates and the material properties of the river bed and rock structures. The constraints are how large, small, smooth, or flat, the rocks are and how well they are aggregated and layered and the amount of stratification of the layers as the result of river sorting properties of rocks, pebbles, and sand. Changes and feedback in the flow caused by changes to other channels in the system also act on the total flow systems in the channel. The emergence of new channels can be anticipated when critical points in flow cause abrupt transition, but the emergent new pattern itself is incalculable. The analysis of the parts, or what can happen will not produce a diagram of the interactions that lead to the emergence of a new channel structure. River dynamics also change when conditions exceed the boundaries of the state space. In an extreme event the river bursts its banks as a bifurcation, forming a new flow system with different banks and flow paths. The flat land of the Canterbury plains is the result of combinations of flows changing from laminar to turbulent, and system bifurcation points that select completely

new channels at times of peak pulses in the river system. From this we can say that the current extensive state of its grasslands is caused by but not directly identifiable as intensive process that moved rocks, loess and biota over an area that was once ocean floor.

Singularities and possibility space require a commitment to the same abstract architecture and machinic processes that share different mechanical processes, at different scales and consisting of different materials. The change processes of the abstract machines are most easily discernible in far from equilibrium systems, where the effects of intensive differences are most exposed to interrogation. The process outcomes of abstract machines result in the different to and not physically obvious in the final shape of material entities even though they are central to the development of that form. Molecular research, for example, is finding ways to identify the structure and outputs of abstract machinic processes at micro scales, using descriptions that relate to neo-materialist metaphysical terms.

To mimic the abstract machines that result in analysable extensive properties, simulation techniques can be applied to vary the properties of different parts of the sub assemblages and then look at how this varies the resultant extensive properties. It seems that the transport of matter is particularly influential in determining the nature of those emergent properties. From this it seems that at human scale, modelling the effects of changes in the intensive properties of an assemblage by varying of the influence of transport appears to be central to the magnitude and effects of social change. This suggests that transport factors have a dominant level of effect when combined with modelling of all the other extensive changes able to be measured in an evolving system. Examples of those measures affected by transport are number of tonnes of fertiliser, or the number of animals a stock truck can carry, but what the nonlinear effects on an assemblage are of changes to say, fertiliser rates or stocking rates. The changes transport makes here are intensive changes to the abstract architecture of that assemblage. They are the changes where the architecture operates consistently with Odum's tripartite altruistic feedback and feed forward mechanism.

Governance systems considered in this way are also real entities with emergent properties have the same ontological reality in social systems, as do the emergent properties of governance systems in natural systems. While social governance systems include and require the presence of human minds, that doesn't mean that human beings have a different ontological status to other entities in the system. That is because transport ontology commits to human beings themselves being part of natural system of the earth with the same contingent existence as all other entities.

Having knowledge about to the processes resulting in novelty in the world requires a commitment to the reality of emergent properties of real entities that are formed through assemblages of a range of materials. This in term allows that transport systems operate within these heterogeneous structures, helping to bring out the content and expression of the entity. Transport mechanism operating as assemblages themselves are very influential in shaping the emergent properties of assemblages because their power to affect is high due to their consumption of high quality energy and capacity to move materials close enough to interact in the formation of new entities with new properties that are analysable but that are not reducible.

Energy flow when considered within transport ontology is a prerequisite of emergence. Energy is transported through flows of heat, or chemical gradients from one place to another bring about the opportunity for material interaction. That flows of energy and matter are described alongside transport processes at the instantiation of the first cellular organism offers insight into the birth of the first living entities on earth. Transportation processes here support a meta- ontological commitment that allows opportunity for all life forms to draw environmentally available energy into themselves where it can be harnessed by processes such as ATP. Flow is therefore a material implication of transport, so everywhere there is flow it can be assumed that transport exists to create opportunity for new, evolutionary assemblages.

Immanent properties and epistemic acts are possible through a commitment to the existence of material and chemical information that flows in systems. Transportation capacity can then develop in entities that use information about their environment to act on local materials to further increase the flows of materials. Transport can then be described a function that increases the inward flow of materials to assemblages, and so demonstrates its highly influential power to affect the emergence of novel properties. Time also exists as part of the abstract architecture of the directional flow of energy and as a property of the segmentation of the concept of 'the plane of immanence'. This structuring property of movement and time leads me to consider that the uni-directional and non-reversible processes that create entropy in energy-matter space have the effect of creating a time dimension, where as part of its abstract architecture of an Einsteinian energy/matter conception, the resulting material assemblages probe a defined possibility space to produces new entities with novel properties¹¹ in a dimensional environment

¹¹ This idea has speculative value but is not essential to setting out a naturalized ontology of transport processes. It develops the relationship if ideas within Deleuze's plane of immanence and Swenson's minimal ontology.

5.7 Material assembling and disassembling

The central concept DeLanda brings to neo-materialism is a commitment to a process where contingent forces engage to form an Assemblage. DeLanda develops the ideas of Deleuze, who theorised these ideas in *A Thousand Plateaus*, using the French word 'agencement', translated as 'assemblage'. The word is intended to describe activities of intensive properties that actively entangle a number of components joined by relations of exteriority. The meshed ensemble creates what DeLanda calls an Assemblage. A problem with the word assemblage in the English language is that it suggests a static structure, whereas the core properties that the Deleuze and DeLanda both attribute to 'assemblage' refers to an active group of assemblage processes. A definition covering the two aspects that encompasses this idea is that an assemblage is made up of entities that continue to be parts within themselves but create a new entity whose properties cannot be reduced to properties of the parts when it is assembled. The identity of an entity can be defined by its tendencies and capacities. Properties are always actual as when then they are manifested or exercised, but tendencies and capacities can be real without being actual (DeLanda, 2002).

Transport systems are assemblages that operate in regulated environments and distribute goods over large geographical areas. As assemblages they have high inputs of high transformity fuel energy and move high embedded energy content goods. On both counts transport assemblages pass the test of being able to affect and be affected by other assemblages.

Territorialisation and deterritorialisation are the ends of a continuum that seeks to explain and situate the way diverse elements in assemblages are related. Globalisation is a form of deterritorialisation as borders are softened, while territorialisation changes come about at time of conflict and war where neighbourhoods become delineated or physically separated. The building of the Berlin wall was an act of territorialisation. Deterritorialisation is the breaking up of boundaries or softening a boundary to the point that it becomes another function. Sub assemblages also have processes of territorialisation and deterritorialisation operating and those changes can influence the overall nature of an assemblage.

A way to gain an idea of assemblage thinking is the process of the consolidation of goods for shipping. A container of consignments that individually constitute less than a full container load can be aggregated in a single container load (LCL) of goods. Considered now as a new entity it consists of a metal box with doors that is built to house and protect its contents – a heterogeneous collection of consigned goods stacked in the container. Each consignment may itself be an assembled collection of smaller consignments. At the next level up, a train pulling containers on

wagons is also an assemblage where the parts include containers, and includes an engine, a driver and communications materials and rails on a road way.

Returning to the container of LCL. The LCL assemblage entity has a consistency and grouping properties through having a common destination and common documentation number. The contents are highly territorialised by being within a rigidly defined space, and the LCL container movements are highly coded through a common manifest destination number, rules of cartage, as well as strapping, stretch wrap and other connecting materials. The LCL container of freight is not a seamless totality. As an assemblage it has properties not found in the cartons of goods and so can be considered irreducible and at the same time analysable.

An assemblage defined in this way has different properties to the material properties of a whole as described in Hegelian philosophy where an assemblage is irreducible and only some aspects can be distinguished. Hegel, who argued that wholes are irreducible, would describe an LCL container as just an aggregation of a mixture of boxes, where the larger LCL entity has no additional properties to those attributable to the boxes.

The LCL container as an assemblage has an identity and functionality not found as properties of its parts, while at the same time the parts continue to have their own properties where some more than others influence the properties of the LCL container assemblage. The history of how it came into being can be tracked through the movement of its component parts, the processes of loading and stacking goods, and the creation of transport documentation. When containerised transport first came into use their properties of secure passage, outer packaging benefits and reduced handling modified then modified, as a feedback result, the way that goods were presented for packaging, and the viability of moving goods over distance in a viable way. The history of how the container itself was constructed is known and can be explained as can the way 'the box' acted back on developments to the intermodal goods movement systems (Marc Levinson, 2006) to stimulate a nonlinear expansion of its use in social systems. An emergent property of a container of freight became a property of change to logistic assemblages generally. The LCL container and its contents have a unique identifier, a binder of a common existence until the assemblages 'death' at the time of unpacking of the goods. As the goods leave the container the degree of territorialisation then changes, and the goods become reassembled with new highly coded information about delivery, customs and payment and so continue as new assemblages of stored and delivered entities. The empty container's status also changes as the particular assemblage deterritorialises. It still has status as assemblages of containers for hire; an assemblage of its materials components that form a shape that can be moved and stacked and as an assemblage of empty containers in a container

park. While this example is simplistic, it introduces assemblage terms and concepts that apply in all assemblages at every scale within transport ontology.

Assemblages are a coming together of heterogeneous elements that are entities in their own right and result in a new entity with emergent properties that are not found in the elements that formed it. Also, when assemblages come together, or disperse, their component parts retain their own properties, while those properties interact in a process of 'transformation' or the actualisation of the virtual. The virtual, as an ever-present possibility is always real and exists independently of whether they are actual. Assemblages offer a theoretical basis and a major analytical device for understanding how transport fits within the mechanisms of independent intensive processes.

Assemblages are always contingent entities that are subject to changes in territorial influences and governance, or rule changes. Over time this may look as though systems are in constant turmoil, but if an historical account were analysed in detail the factors of territorialisation and rules could be uncovered as the life, death, and history of that particular entity. Components of assemblages consist of components with material roles that are functional and components that are expressive.

Transport studies may better be considered as a probing of assemblages found in the sciences of other fields with 'affiliations and alliances' of the physical 'graphy' domains and with those that deal with the physics of load capacity and power and distance, and the social –ology sciences of material interaction through communication as speech acts. To unpack transport as an evolutionary and social entity, we need to get away from a metaphysics of 'seamless totalities' and focus on types of intensive relationships that can be found within assemblages.

A way to describe transport in an assemblage like that would be to call it part of a pattern of emergence. This consideration of the abstract is what Alexander observes in urban architecture where he says that individual acts generate larger global patterns (Alexander, 1977). In his work he searches for something to connect humans to the universe. He searches for 'an underpinning for the structure within which we live. He says that patterns emerge organically and 'almost of their own accord' (1977) This suggests that humans can be acted upon by the emergent properties of structures in ways that in turn influence human action. At a social level he observes that the act of building structures causes larger patterns to emerge, and that the creation of boundary areas gives life to a way to express their identity. This is consistent with the properties of assemblages that continue to have the properties specific to, say a specific subculture, while at the same time giving rise to a larger assemblage with its own specific culture that in turn moderates and influences the members of the subculture.

Allen warns of the perils of too detailed an analysis on assemblages (Allen, 2011). Some parts of assemblages can be accepted as having a functional role. The problem of how to gain useful insight about what to look for when assemblages are altered remains. He says that accurate predictions are proving to be very difficult to make (2011, p. 58) but while development and change happen, this theoretical approach is of little use without a methodology and field examples. If we accept that the world comprises a multiplicity of nested assemblages the interactions of which need to be studied and understood for every individual act, then we have a problem of application for this theory. A solution emerging from my research is to identify transport as a primary focus in the composition of assemblages and that the outcomes of some sub assemblages can be assumed and not over analysed so that the focus becomes to only concentrate on active assemblages that can bring about novel or significant consequences. The issue is how to identify them. There is a need to identify parts of assemblages that most influence the new identities that are created. Candidates for these can be found in historical analysis but may not automatically apply *a priori* to emerging assemblages.

Looking at it in another way, where an assemblages' properties are not part of the main assemblages of interest to any project, then their unique properties can be taken as a given. For example, if an assemblage such as a driver, a truck and a coal carrying trailer is of interest, the assemblage details of the engine of the truck are unlikely to come under scrutiny, apart from its ability to move the load. The coal truck as an assemblage of high transformity energy will have the capacity to affect the assemblages of coal mines, industry users and other road users. High intensity measures of parts of an assemblage can indicate that the assemblage may enter intensive zones - the crumple zone of possibly space, where the production of novelty could occur.

Where feedback mechanisms are growth stimulating, such as using high transformity energy used to transport fertiliser, which is itself also high transformity energy, the value to farms is the boost to lower transformity energy of pasture growth that so leads to an increase in overall production (see Figure 11). This is also the case for intensities of land use such as increasing dairying on gravel plains where power, water, and fertiliser and large numbers of cows are transported into the farm assemblage over a short period of time.

From the LCL goods movement example above, we can see that assemblages mix parts at many levels and complexity. To illustrate this, we could use a canoeist as an example of an assemblage, where a canoeist, the paddle and canoe together produce a new entity in the form of a waterborne machine that has new properties and new capacities to affect and be affected. The affects that this assemblage of a canoeist has, on the way trade is conducted for example, cannot be derived from

looking at the canoe, or examining the person, or describing the paddle. As an assemblage the canoeist exhibits new emergent properties not found in the analysis of the parts or as a sum of the parts.

The schematic diagrams of Swenson and Odum indicate how feedback paths lead to system complexity. In this way an energy transformation process is also an assembling process that has a bottom up mechanism and a top down mechanism. The same mechanism may also be the case in social systems. As people group together in villages and towns the effect of the group brings about a need for collective management and control of the space, via the implementation of rules that apply for all those in community. As the community takes shape as a new entity, properties develop that are not previously found in individual households. These properties emerge from the complexity within the community within which they are generated. The emergent community can then legitimately feedback territorial and behavioural controls over its individual members through rules and sanctions. Community governance organisations, resident interest groups, and the like have emergent properties that are real and influential on how the village develops into a town. This leads to realist theories and materialist ontology, and social commitments mechanisms such as those developed by Lawson (Lawson, 2012) and Offer (Offer, 2006).

I have explained the neo-materialist basis of my approach to the ontology of transport and how it is articulated via the idea that all material entities are assemblages. A neo-materialist philosophy can also provide a grounding for the processes and language that describe the nature of the abstract architecture of wide-ranging complex systems. The metaphysics of neo-materialism provides ways to discover and explain the common principles and abstract architecture that give transport processes a place and a set of common principles that underpin its execution within diverse complex systems. Central to methodology consistent with neo-materialism is the existence of entities as assemblages, where self-organisation and morphogenesis generate novel structures. There are implications for both predictions and simulations where the capacity to be affected is very large and wide ranging and dependent upon how attractors and bifurcations structure the space of possibilities. Here specific properties are unpredictable but informative in understanding how transport within emergence is part of the process of creating novelty.

Understanding the primacy of the structure of matter and energy flows may offers a partial solution to a better understanding through simulating the characteristics of abstract machines that operate within possibility spaces that are bounded by 'a space pre-organised by attractors and bifurcations' that limit the space of possible forms. The nature of emergence rules out prediction of specifics

however, through simulation offers ways to understand the creation of main forms within a possibility space but does not predict the particulars of new emergent entities.

with a way to start is through an understanding of what the immanent features are and draw out what you want to better express through an understanding of the territorial and coding parameters. Neo materialist philosophy coupled with current scientific theories and methods provide a principled account for the emergence of life in general. To ground a new approach requires clarity about what kinds of beings, or things, or forces in the world must be considered as legitimate and that then flesh out a robust framework for all the different types of transport activities so far identified and considered in preceding chapters.

A commitment to the material role that active transport processes play in the creative processes of assembling and disassembling real entities is central to the metaphysics of naturalised transport processes. It allows for different types of physical assemblages that have the same diagrams are generated by the same abstract diagrams and are mechanism independent. Changes to parts can change the properties of the assemblage depending on their overall significance. The concept of an assemblage addresses several problems of the relation between the parts and the whole and emergence of new properties. To illustrate, transport systems can be seen as assemblages of assemblages, and are structure generating processes that result in strata's and hierarchies (DeLanda, 1997, p. 185). An Assemblage can then be accepted as the interaction in a state space of existing assemblages that act together to form a new assemblage with its new emergent properties, while the contributing assemblages continue as whole entities that maintain their own emergent properties. Assemblages are therefore analysable but not reducible. Simulations are a tool of assemblage analysis, as simulations can manifest the behaviour of intensive processes of abstract architecture. The understanding of the influence that intensive properties exert within matter in assemblages can be increased through mathematical simulations that approximate the abstract architecture of the causes that produce entities. Abstract architecture and mathematical simulations are not the same thing, but they overlap in their ability to make abstract processes evident to a degree that is meaningful in this context. An exploration of possibility space in transport systems is an area where research could be fruitful. A better understanding of the shape of possibility space would help explain emergent mechanisms. An assemblage within this commitment is the resultant and real entity formed through interaction and relations of externality within a group of already existing entities. Those contributing entities continue to be analysable in themselves, as well as components to the assemblage.

5.8 Chapter summary

The transport ontological commitments described in this chapter allow for and situates transport within the essential activities of a living planet. The ontology commits to the existence of active presence of transportation within thermodynamic flow processes and at all scales. Transport is best theorised in a realist material ontology, with its commitment to a mind independent existence of the world which allows that one event objectively produces another event.

A naturalised transport ontology allows for an account of different types of flows, where there those combinations include informational flows that in their nature are a type of material flow. These are low energy cost flows of 'information about' that tell or signal food location and spatial orientation and so are flows of perception and information about the state space where transport happens. The commitment in an ontology for all living things having 'information about' capability requires that the *living thing and their environment* constitute the definition of the entity. The commitment to transport ontology increases sensitivity to the influence that the historic context of how structure develops in time and space as the result of an evolutionary understanding of energy flow as selecting for processes that create order as soon and whenever possible in an end directed manner. It arises from the proposition that 'transport' as a function began at the earliest development of life and movement. It allows for further theorising on a material explanation of the development of both structure and form in evolutionary development. The ontology allows the material evolution of the world to follow nomologically, with evidence and similitude in production mechanisms and scale discoverable in all living systems. The informing of this naturalised transport ontology has been the findings of a concomitant if passive discovery process within evolutionary biology that have opportunistically been aided by medical research on cell transport systems that find transportation of matter at the molecular level to be similar to those of a human social level.

In the following chapter I combine elements of Lawson's critical realism and his insistence on social ontological clarity, with the materialist ideas of energy and entropy flow to show how Swenson's central posit that the 'world in the business of order production' applies to social systems as well. Lawson's social ontological project offers a descriptive framework of control and feedback processes in the human social world (Lawson, 2012). He contends that social ontology supports rules within social systems that can assist with assessing the underlying assumptions of economic evaluation of transport in systems and social complexity. This approach to 'understanding the world' is not without its problems. Evolutionary biologists are addressing these issues, and Kovac's work in positioning human beings within this world, helps explain our evolutionary adaptation to what we perceive in our environment. Kovac also addresses the disruption of metaphysical thought

that human enquiry into the micro world that science offers through the use of scientific instruments. Kovac makes the point that while scientific enquiry creates better scientific artefacts (microscopes and telescopes for example) humans continue to process that information using Aristotelian philosophical understanding. Scientific artefacts enabled the enlightenment, allowing Gauss to describe the behaviour of gas in a bottle, and for Newton to quantify aspects of a clockwork universe. Darwin described how species selected traits and why the fittest survived but as Swenson argues, it remains a theory that presupposed evolutionary development; a situation that leads to present day reduction of evolution to a gene issue. What Lawson and Kovac address is the need for metaphysical thought that is coherent with contemporary scientific discovery.

What the ontological commitments made in this chapter mean for transport is a new opening for discussion about a broader neo-materialist understanding of the metaphysics of all systems within which transport processes are found. The important point then about my transport ontology is that it encompasses all living systems, and that includes human systems.

Chapter 6

Application to Social aspects of transport

“We have seen that things pull together flows and relations into various configurations, whether the things are molecules and atoms, or whether they are books and computers, or whether they are institutions like schools and societies. For a period of time matter, energy and information are brought together into a heterogeneous bundle. Things assemble. We have seen that things are not isolated. It is in their connections, and in their flows into other forms, that their thingness resides”

(Hodder, 2012, p. 8)

6.1 Introduction

In this chapter I argue that the behaviour of the transportation of goods in social systems can also be explained in terms of a realist and neo-materialist ontology. I apply the methodology of DeLanda’s Assemblage Thinking to consider how transport development forms part of the overall material determinates and structure of social systems. What emerges from this chapter is an expanded methodological framework that includes realist aspects of social ontology that are consistent with transport ontology and neo-materialism. The alignment of transport and social ontology is then discussed in Chapter 7 using examples of transport processes in social systems illustrated by examples in Chapter 7. The major challenge of this chapter is to consider the presence and interactions of human minds in decisions about ways materials are transported. I approach this by explaining in neo-materialist terms, how in principle the structure and operation of social institutions and social interactions form part of the same materialist and historical evolutionary context as all entities in the world do. I argue that human decisions are also material interactions within assemblages that are embedded in an interacting materially active world. In developing this argument, I show that the sustainable and persistent life and health of communities, towns and countries are not adequately accounted for as chance outcomes of individual human choice alone. I identify aspects of human social interactions and institutional influences on transport systems that are subject to the same transportation systems abstract architecture as found in other interacting systems and at a range of scales.

I have argued that pre-human transport systems became highly developed as active processes within an ordered world without the need or presence of human minds. Those same material non-human influenced processes continue, with the latterly added impacted of human social assemblages and decisions made by human minds. Adding human activity to naturalised systems creates a whole new epistemic dimension that needs to be factored into a neo-materialist account of the way transport systems develop when conceived and then planned in human minds. This requires consideration of how humans make transport decisions that influence the quality of human life, and whether those decisions are made in a way that is explainable within the commitments of a neo-materialist transport ontology. This sets the anthropocentric view of transport as primarily a tool of commerce against one where transport and material processes of human society, including culture and choices, control and are controlled by material flows of natural systems. Scale and timeframe become important here. At one extreme commercial health is measured in quarterly increments, whereas the cycles of the Earth's systems are measured in millions of years. The key point about the way a transport ontology includes human systems is in the capacity to affect and the capacity to be affected by changes that transport makes to the overall material environment in which those systems are embedded. The role of human agency and power in the 'age of humans' – the Anthropocene, may be reinforcing modernist beliefs in the divide between the natural world and the world of human culture (LeCain, 2015).

6.2 Social systems and economic implications

The concept of goods in an economic sense is something that is intended to satisfy the wants or needs of a consumer, and the effectiveness at doing this is considered to be their utility value. Economic theory concerns itself with the social self-other relationship but more so in a self-self, mechanistic relationship through an economic obsession 'with dressing up in the methodological clothes of physics' (Fulbrook, 2009, p. 76). In this type of economic system an individual is expected to transact with another individual in the interests of self. The narrowing of the role of transport in a context like this to that of being a derived demand to satisfy the distribution of goods is a direct outcome of the influence of neo classical economics, where the focus is on individualisation of wants and needs and the sovereignty of the consumer is all important. This focus resulted in a lessening of the importance of the process of shifting something of tangible value (such as potatoes) to an actual market place. Classical economic models still tacitly acknowledged the work required to make the physical connection between land and transport as a source of wealth, and the social structure it supported. During the Enlightenment and Industrial Revolution, the definition of transport within economic orthodox theories became progressively reduced to the study of a

mechanistic and isolated function serving markets that lacked the definition of Smith's original local village trading marketplace. Transport portrayed in this way is reduced to distance, tonnage, and by the 1980's explanations such as Christaller's Central Place Theory created a platform for economic based mathematical modelling of transport geography constructed on neoclassical axioms to dominate thinking. For the last thirty years, the transport function has been cast almost exclusively in economic terms as a derived demand and if there is criticism and opposition to this, it is muted and ineffective. This included a lack of need or development of a more general goods transport theory.

Rittel, a professor of the science of design, and Webber, a professor of city planning, are not optimistic that a scientific base can be used when confronting social policy problems. In fact, they say they are bound to fail as problems of social policy are in essence non-linear and non-scientific with no definitive solutions (Rittel & Webber, 1973). It is interesting to contrast this situation with the description of cellular information systems, and what is known through the mapping of the complex relationships within and between cells and their environment. In that environment it appears that the social policy problems have been solved, and the collective good of all within the boundaries are constantly monitored and the system modified accordingly. This approach to 'problem' resonates with the communication networking of Checkland's (1981) Soft Systems Methodology that recognises that the problem solving process becomes part of the learning process and is self-modifying where the solution of one problem influences the solutions of other parts of the problem. It is discursive in the positive sense that while reaching consensus may be a lengthy process and expand in its scope to include extra material apparently not essential to the topic as firstly understood, it has the potential to enable a pathway towards problem definition.

At the heart of policy management there are always new forces requiring policies to address new circumstances. Easton calls this 'ongoing modernisation' (Easton, 2008), and with the sources being technically complex, globalised and with social change and aspiration; lead to forces resembling Geel's 'dynamically stable' socio-technical regimes that undergo transitions.(Geels & Schot, 2007). However, what follows from transport ontology as developed for this thesis is the requirement for hierarchical governance of some function as well as network exchanges to be monitored as they adapt, adopt, and self-modify using self-feedback mechanisms. What we learn from the stability of cell design is that energy flow is what ultimately governs the health of the organism and so its evolutionary trajectory depends on access to energy.

This suggests that the rudder guiding the ship of policy needs to consider the stocks and flows of energy through the organism or organisation, and specifically address the implications of finite

stocks of low entropy energy, and how these fit with policies supporting short term decisions on energy use that can be summarised as 'burn it all now'.

The work of HT Odum and Swenson supports a view held within ecological studies that all systems share a common framework of some sort or other. Students of H.T Odum found that "What was astonishing for us was the realisation that the systems and energetic principles that we were learning and applying to rivers and estuaries in North Carolina could be equally applied to human-dominated systems" (Hall, 2005, p. 13). The possible similitude between human systems and natural systems was an interesting notion that led me to focus on the nature and importance of energy flow for all human endeavours – with freight transport systems being one specialised application. The practical question of what sort of link there is between transport growth and GDP growth does not seem to me to be answerable in the absence of a full consideration of transport as part of a living system, and where energy flows are left out of the equation. Conversely, fossil fuel is a factor in the correlation of economic growth and energy use (Ayres & Warr, 2004; Warr, Schandl, & Ayres, 2008) with a close analysis of fossil fuel availability (Robelius, 2007) showing this to be a vulnerable point in looking at future development.

Rodrigue views transport not as science or an industry like cotton weaving, car making or dairy production. He focuses instead on how it functions within the current economic framework (Rodrigue, 2013) where the development of transport systems remains a distinct social function responsible for creating complexity and relationships that in turn required a governance mechanism. In support of this Lawson argues that the level of control and complexity in society is controlled by social rules that can be studied and are as real as those found in any physical system.

The possibility of transport being used as a controller of the health of social systems emerges from identifying transport functions in thermodynamic and evolutionary systems, and how this affects cellular and ecological systems development. An acceptance that processes seen in nature are reflected in social systems is consistent within an ontology where transport is a consistent connection between material flows and energy flows that result in living systems. Accepting that social systems are in the same evolutionary and thermodynamic world as cellular and ecological systems allows for a translation of and unification of transport functions and a comparison of features.

The volumes of material and distances that goods are transported continues to grow and support a political-economic and financialised global economy. When framed within this Neo-Liberal Economics framework transport exposes each entity to risk as borders become transparent and

money flows become opaque. The neoliberal view held since the 1970's is the dichotomy of the intent of Classical economics, practiced by the likes of Smith, Ricardo, Marx, Keynes, Schumpeter, Fisher, and Minsky, with its understanding of dynamics, impacts on social classes, emergent phenomena, complexity and evolution. The liberalisation of markets increases competition between geographically separate markets through the removal of barriers to entry, price control and licensing, and changes to taxes and subsidies that may discriminate between businesses and different related markets (Easton, 1997). For New Zealand the implementation of this ideology included a reluctant restructuring to address a range of problems (Easton, 1997). Three of them directly affected transport, being, transport deregulation, the energy problem, and an insulated economy. All three are factors of cellular and ecosystem health and require complex interactional communication to ensure the health of the organism. The ontology allows that complex systems at any household scale monitor the management of all activities' throughputs. From this study it is questionable whether market activity, as envisaged by Smith (who was writing in a pre-industrial time) is the same type of 'market' activity that moves commodities between distant communities without any social attachment to those with whom the goods are exchanged.

One thing not to have changed during the rapid complexification of the world and related expansion of cities, enabled through cheap oil, is the definition of transport. Is modern transport still performing the role that Cooley described, or has it changed? There is a large question about what the finite stock of petroleum plays in the evolution of the world this century. Transport has played a central role in building an oil fed economy, but is our understanding of the role of transport in the world writ large – to the evolution of the world - sufficient to keep civilisation on the rails?

The only absolute scarcity in the universe is low entropy (Dryzek, 1987), for which there is no substitute. As Dryzek put it:

How do you recognise an ecologically rational structure? They are highly ordered and have low entropy so can cope with stress and perturbation (disturbances caused by secondary influences), so that the structure can consistently and effectively provide itself with the good of life support. Rationality is closely associated with self-regulation as the wellbeing applies to the system as a whole.

(Dryzek, 1987)

I have traced transport processes back to the development of the first cells 4.5 billion years ago and shown how transport actions brought together energy and matter, or where part of the physical junction of the thermodynamic movement of heat from within the earth and atoms from the sea.

The combination of environment heat and chemiosmotic activity in a physically discrete space enabled a concentration of atoms to create potential across the border of that physical space. The combining of transportation and potential energy is then followed through to the formation of prokaryotic cells as part of the identity of a persistent self of the cell. Transport systems facilitated the internal mechanisms of the cell, and the movement of food and waste between the confines of the cell and its environment through formalised transport mechanisms such as cilia and passive and active transporters.

Transport is an intrinsic part of the co organisation of the self and other dynamic relationship of the living cell in its epistemic and interacting environment. Calling the environment 'interacting' invites transport and thermodynamic activity in the world to be considered as equally important to those processes within living cells, organism, or macro organism at every scale through to the level of invertebrates. My transport ontology recognises that this is critical to a unified view of how transport interacts with all the formation and maintenances of all living processes.

The ontology also allows for a concept of informational intelligence, or that described as physical, or natural intelligence. The importance of border control at any scale can be expected to be of similar importance. Cells are being described as highly cooperative and exercising extensive transport signalling as part of the active governance that is characteristic of its historical evolutionary and thermodynamic base. The work of Odum and Swenson flag the likelihood that there is natural intelligence by the inclusion in their models and theorising of energy flow as providing an epistemic aspect of evolutionary development through self-feedback catalytic mechanisms. It seems that autocatakinetic processes do underpin the self-other concept ensuing the persistence of low entropy beings within flows of potential energy within a background environment that provides a high entropy heat sink.

6.3 Common features in social systems

Within social systems there are events that are regular and predictable, and for a realist account of these they need to be explained without reference to ideal forms, or essentialist argument where physical entities are regarded as 'faithful realisations of ideal forms' (DeLanda, 2002, p. xiv). Regular and predictable occurrences need explanations that can be understood as intensive processes within assemblages. A non-human example of this is how the contingent form of bacteria has remained unchanged for billions of years. Once bacterium as assemblages became able to extract the maximum energy out of their material space, they stopped changing. We can say from this, that the contingent existence of anything in the world may reach a resilient or optimum state, where

energy flows and relations of exteriority of assemblages are maximised, the assemblage will continue to function in the same way. The attractive behaviour and directionality of machinic singularities and of entropy flow provides a degree of elasticity for systems with changing environmental pressures. Resilience of the system within an environment as a phase means that a system will recover from and adapt to some changes, and the capacities of the whole will continue. For bacteria the maintenance them when considered as an assemblage depends on the effectiveness of boundary control where that membrane controls what is transported in and out of the cell in the interest of persistence of being for the cell.

What applies to cellular systems also applies to human systems that are also subject to variable energy inputs and this explains how assemblages with a human content change in response to the same abstract architecture controlling the processes of growth. At times of strong growth. Odum identifies transport and advertising as being inefficient growth priming activities in terms of their internal activity but as particularly influential feedback processes in stimulating growth in human systems. While being inefficient and exploitative in growth situations transport and advertising act within assemblages to create tangible benefits to human quality of life.

Viewing transport through a neo-materialist lens we can say that when energy flows and materials combine in the human social world then transport systems with similar abstract architecture as that found in prokaryotic cells will reach similar contingent states. This will eventually develop via probing, experimentation, failed ideas and finally through materials movement systems contingent on the same virtual mechanisms that act on cells. In current society this is hard to see where free energy flows fluctuate and change in time scales of months and where the thermodynamic aspect of evolution is not recognised as important and thermodynamic theorising focusses on entropy as being primarily a statistical understanding of the degradation of energy flow. The fuller realisation of human persistence as always being within a material and natural process may take several iterations of experimentation and fluctuation. Conceivably this could happen over millennia until energy flow into the world systems in total, equalises with the energy flow sustainably available through the natural world, and that includes human systems persisting without the short-term boost of hydrocarbon energy in the natural world.

In the overall evolution of the world, human systems may still be in a probing and experimental mode and possibly not optimised for survival. An indicator of overall progress can be gained by comparing the level of transport development in cellular and ecological systems and how human's systems are approximating the level of natural technology within a cell. A combination of the

introduction of system power via heat engines with recent developments of networked communication suggests a human equivalent move from prokaryotic to eukaryotic complexity.

Current social thinking about transport confines it to a tool to improve access to a better quality of life without much regard to the efficient integration with material world flows and systems. An example of this is that if we want goods to travel faster from Auckland to Christchurch we look at the current transport system as a thing to be engineered to improve efficiency. The reason these goods are moving, and how fast they really need to travel are secondary considerations at a time when transport processes have access to high quality energy at low prices. The anthropocentric imperative is the control of the movement for the perceived betterment of an individual's situation.

As suggested above social examples of assemblage theory has a structural similarity to understanding the social dynamics of change as expressed as system resilience. Both have the same general idea of a basin of attraction, a feature that is explainable by the idea of a shared possibility space of the two manifestations. Neo-materialism creates a way to meaningfully consider that all aspects of society have material causes. Marvin Harris' theory of cultural materialism is a theory in this possibility space as an example of how social groups work and are worked on within a more granular combination of infrastructure, structure, and superstructure. He says that these interactions at a range of different levels means that behaviour of physical systems is always part of the behaviour of the whole, and cannot be well-understood as a conglomerate of local events acting by themselves (Harris, 2001).

Language is a particularly interesting material. Children are taught language as a labelling process, where syntactic patterns result, via replication, in cementing them into a social context. For example, children in New Zealand are subject to social norms from birth. The direct control from an early age is that in this household you learn to speak (say) English, and the label for this object is a 'spoon', and that is a bowl. The spoon and bowl are not mental entities, but material objects with specific usefulness the properties of which are summarised by a specific name in that particular place and time. Consistency of use in a household and social group means the referent of the word spoon is an object shaped in a certain way to hold liquid and to be held by a hand. This general concept with the label 'spoon' is what we learn as a social obligation and crucial to understanding language (DeLanda, 1997, p. 190). 'Spoon-ness' doesn't take its meaning from an ideal form situated in an immaterial space. This illustrates the place that non-discursive practices have within a prevailing reality where those practices are reinforced and insisted upon by social obligation (p190).

The informational aspect of a materialist and realist ontology of emergence treats all information as being embodied in processes or in physical things, as they are in non-human systems.

Commensurate with the concept 'to affect and to be affected' information has a physical aspect of 'to inform and to be informed'. For human information to exist there must be the presence of human minds to assess how information affects action. If all human minds vanished, then information in the form of books, signs, computer software are reduced to physical objects only.

6.4 Social ontology

As established in Chapter 5, neo-materialist metaphysics is underpinned by ontology that treats all entities such as individual communities, organisations, and cities and even nation states as individual entities. These entities have the same ontological status as the individuals that are involved in social processes. Each entity is the result of an historical process, and not a finished product. This approach means there are many more levels of influence on the structure and operation of transport systems than those of the individuals, groups, and societies. There are many assemblages of influence including human minds (relationships, institutional rules etc) that affect and are affected by social material flows through social and industry networks. As assemblages these have capacity to affect and be affected and to feedback and control an individual's actions through encouragement and ostracism within many assemblages at different scales. One transport feedback system is the car horn. It can be used to express thanks or dissatisfaction with the driving of others.

I have argued that transport systems are part of assemblage processes at a molecular level in cells, and that every organic process has a beginning and an ending. The same ontological commitment applies to assemblages in social systems at every scale where their beginnings are historically traceable and contingent in its reality. The reality of each social assemblage can therefore be confirmed by an explanation of how it came into being. Within social assemblage transport systems have the capacity to operate with the same abstract architecture innate in material interactions of all kinds. The walled city of Dubrovnik (Figure 36) for example has a similar structure to a biological cell with its walls and gateways; access to food sources from the sea, buildings, acting as internal membranes connected by transport routes. Structures, or organelles for governance, exchange control and defence made for a persistent entity of power and control over the surrounding environment.

The properties of the social entities that govern transport within transport ontology are also real and exist independently of how we think of them. That is not to say that they exist independently of the presence of human minds per se, because without human minds there would be no human



FIGURE 36 THE 'CITY CELL' OF DUBROVNIK

SOURCE: MICHAEL PHILLIPS WIKIMEDIA COMMONS

social reality. The ontological difference here is that social structure exists regardless of the *contents* of a human mind. For example, an individual can assert that road traffic compliance agencies don't exist. However, regardless of what they individually think that person is subject to the issue of traffic offence notices, required to attend court, and be financially

penalised for breaking the rules of that institution. These are material social processes shared through language that govern behaviour. The beginnings of all institutions can be traced to a formation point where one way of operating defers to a more complex one, and the reality of its functioning the continues regardless of any one individual within the structure.

The same ontological commitment to human systems is argued to exist in all social systems where transport exists. Socially real transport systems are not confections of the choice of individuals within the context of a dichotomy of 'individual choice' and an all-encompassing conception of 'the market'. Neo-materialism does not accept such reified generalities but insists instead on interactive individual heterogeneous assemblages at different scales of reality, all of which have emergent properties dependent on their component parts. This ontology is significantly different to the presuppositions of modelling used to understanding how humans organise their habitat. It provides a way for a deeper theorising of transport and social health.

An example of similitude at a societal level is expressed by Lawson, who as a researcher at Cambridge University philosophises about what constitutes social ontology. He describes social phenomenon as always emergent and as a:

*'stratum of reality, and indeed each of its members or constituents, can be said to be emergent,...if there is a sense in which it has arisen out of a lower strata, being formed by principles at the lower level; remains dependent on the lower strata for its existence; but contains causal powers of its own which are both irreducible to those operating at the lower level and (perhaps) **capable of acting back on the lower level**'*

(Lawson, 2004, p. 17) (My bold).

Lawson here characterises a stratum of reality as possessing emergent powers where they come out of a lower stratum, being formed by principles operative at the lower level. He says they remain dependent on the lower strata for its existence and so his is a description of social structure that has similarity to Odum's thermodynamic hierarchical structure where levels operate independently but also depend on each other. I quote Lawson (above) to emphasise how similar the description that he gives is the view HT Odum has of the world and how similar his concept of emergent entities in social systems is to those of both Odum and DeLanda. Lawson shows further similarity of structure when he also says that the social rules exist in social reality and consist of complexes that are irreducibly structured.

What I am proposing as transport ontology that has commitments that explain social systems is that transport be regarded as an integral part of iterative growth, governance and sustainability that is controlled at many institutional levels. Transport theory can then be informed around its influence on the causal properties of flow and feedback mechanisms that moderate the health and structure of living systems. It allows for processes of movement envisaged as enabling directionality and that are consistent formational flow within entities that gives power and meaning to transport in a social context.

Lawson's initial enquiries into ontology of social systems was through a dissatisfaction of a 'world view presupposed by the methods used' in the formalistic models in economics (Hirsch & DesRoches, 2009). Behind the problem of the apparent lack of concern that all models have limits to their usefulness, he became critical of the ability to explain social systems that limited the outcome where 'contemporary thinking reveals that all methods fail to facilitate insight into social reality anyway' making formalism no better or worse than any other method (2009). Lawson however persevered with the idea that 'there is a world out there and that we do get to know it under some descriptions', and so he realised he had taken an ontological position on the workings of the world as that of a philosophical realist. He found there to be a failure to ground theoretical perspective where investigatory methods make irrelevant assumptions, or where those assumptions are not explicit. Within a realist view there is an aim and belief in the necessity to make explicit the structure of reality and this drives theorising into new territory. This contrasts with Crotty's account that reduces reality to something emerging from the development of a theoretical perspective which he grounds in epistemology asking 'what epistemology informs this theoretical perspective' and 'were we to introduce it into our framework, it would sit *alongside* Epistemology' (my italic) (Crotty, 1998). An ontology of science must do much more than *accompany* a theory of knowledge

or be used to justify a theoretical perspective. Ontology must make bold and supportable claims about commitments to the way life came to be as it is upon a single planet bathed in sunlight for half of each day.

Lawson's concept of social structure as being 'both a condition of, as well as dependent upon, human action' where 'objects of social reality are inherently processual' perpetuates social reality materials through the reproduction and transformation that replaces both voluntarist and determinist accounts of social life. (Lawson, 2004, p. 17). Lawson argues that processuality characterises all social phenomena, which I take to include systems of goods movement as a form of processual flow through human systems. He says that a key property of social phenomenon is that it is always emergent, and, this has a resemblance to HT Odum's hierarchical energy using structures. Lawson's enquiry into society as processual hierarchy lead him to formulate a definite conception of social reality. He finds among its existents (meaning real or actual, and not imagined or invented) social rule-position-practice systems and a social reality that is structured both vertically and horizontally 'and further characterised by emergence, openness, interconnectivity (or relationality) and dynamism or processuality' (Lawson, 2004). The vertical structure he identifies in social systems includes underlying powers and tendencies as well as actual social practices and other events. Practices are differentiated horizontally. Lawson's conception of social reality has a consistent ontological view of the world as in the business of producing order. Lawson notes that it 'obviously provides directionality to social theorising', and 'in particular, it is suggestive of the sorts of scenarios for which we ought to be methodologically prepared'. To this I would add that neo-materialist thinking offers a direction to social theorising and the discipline is developing a social methodology.

A further application for neo-materialist and assemblage thinking is suggested via Wan's observation that there is an intuitive observation within sociology that society is more than the sum of the individuals (Wan, 2011). He says that sociology remains divided at an ontological level as to what sociology is, and so the discipline supports multiple epistemologies regarding societies and individuals, with a lack of clarity of methods that are appropriate to analyse these (2011). Within a thermodynamically driven living perception action world, issues of social structure and intentionality can be theorised as consistent with economic and organisational science's interest in complexity and emergentist theory. Concepts of end directed order production, and the situating of the individual within this epistemic world enables a commensurate development of social structure with the same basis made by presuppositions of energy flow and organisation in the physical world. Such a stance is within the definition of scientific realism underpinned by knowable mechanisms to

a degree that the methodological stance is close to scientism in its requirement for entropic law-based action in the evolution of the world.

For Lawson, social ontology addresses what it is to be, or to exist and to begin to explain 'what all the things that are have in common' (Lawson, 2004). It is the study of anything 'under the aspect of its being of what is involved in its existing' (Lawson, 2004). The area of focus in a search for ontological commitment is to use the events to identify the nomological character of the assemblage history that provides, through its existence and behaviour, an indication of an abstract architecture. Lawson's description of social ontology offers a degree of structural certainty to the questions asked at the outset of this study. That is: what can we make intelligible through our senses about how the world is? To avoid the shifting ground of postmodern thinking, Lawson allows that the phenomena observed, including event regularities are 'typically aspects of the features of most interest'.

A social assemblage of material things needs an explanation of what it is that binds them together. Offer (2007) identifies and considers the importance of the existence of the role of commitment devices within social communities. Lawson calls such social rules things that exist, whether they are followed or not, in the sense that working to rule is a social thing that suggests 'a rule' exists, where workers threaten to work to rule, and this shows that the rule exists even though it is not usually obeyed. This highlights that there is a material content to the reality of social rules as generated by institutions that allows for existence that is independent of the contents of an individual human mind. Offer (2007) describes marriage, mortgage, and Medicare as examples of commitment devices, as they are socially binding entities that exist to manage and moderate our behaviour over time. The role of institutional and social control is shown here to have precedence over individual choice, so it contrasts with neo liberal moves that decode society through minimal governance, and maximal self-interest where 'rational people think at the margin by acting only in the marginal benefits exceed the marginal costs' (2007). It is a view that suggests humans are now socially unconstrained in access to goods and services just as energy flow is unconstrained in the development of deterritorialised or global transport. This is in contrast with recent materialist thinking that suggests that material flows significantly influence society structure and is argued for by LeCain (2015) and also expressed as a 'co constitution between humans and nonhumans by Muller (2015). It appears that our response to untrammelled access to energy is something that social systems are affected by with human response translated into material changes in social mores and norms.

The blueprint of the intensive pressure of burning hydrocarbons to power motors seems to be a reinforcing loop, where more energy invested results in more energy extracted. We know that a steam engine has a regulator on this cycle but socially we are reluctant to regulate the process when it is part of a cultural process. This at first appears to contradict ideas of system regulatory control as being a natural process. A solution to this is to show how governance solutions that result in the survival of the survivor are achieved. A lack of cultural control over issues that are central to long term social health as understood within this methodology is not the absence of something ethereal, but the lack of a governance tool of social reality (Lawson, 2012) that exists even if some people are reluctant to bound by regulatory control.

Lawson's critical realist approach to social systems enquiry can also be applied to an examination of the flow of energy within systems that have a transport function with the objective being to identify mechanisms that create apparent event regularities. The methodology he uses is to seek more than the first causal explanations of how things are connected and seeks to discover a *naturalised evolutionary account* of the deeper connection of energy flow, social development and interactions through time, space, and language. The methodology employs the technique of retro-duction, by seeking to move from the usual phenomenon of interest and to investigate the way the thing is constituted and establish intentionality and end directed order production in its evolutionary history.

The social role of transport is linked with a notion of social progress and subject to 'conventional wisdom', as defined and used by Galbraith (1958) to describe how 'a very large part of our social comment...is devoted at any time to articulating the conventional wisdom'(1958, p. 10). The conventional wisdom ascribed to the transport of goods is that an increasing production and availability of goods is a basic measure of social achievement. Conventional wisdom of this type provides a source of reassurance and aligns with the themes found in current (transport) research that articulate the intrenchment of conventional wisdom. Galbraith says the enemy of conventional wisdom, are not new ideas, but the march of events (1958, p. 11), and the yielding to 'the massive onslaught of circumstance with which they cannot contend' (1958, p. 17). The material role of institutions that actively brace old ideas against the onslaught of the new both explains and describes the problem. The reassertion of the role of the material could be such a challenge.

Allen (1997) models geographic, regional and urban change 'and their imbedded systems' using nonlinear modelling that simulate the way urban systems evolve. Though transport is not the focus of the modelling, it is inherently a part of the material movement and change of geographical shape within the modelling. Prigogine (1997) in his foreword to Allen's book describes cities as where an

'interplay of system feedbacks and historical events shape the evolutionary process' as some of the non-linearity's that occur when social actors and cultural preference are considered in economic systems and the 'pressures that fashion peoples preferences'. Allen develops dynamic models and sets out the methodological and philosophical basis to his study of spatial self-organisation. In his work Allen can be seen to address complexity starting from a similar basis of historical, evolutionary, and thermodynamic processes with many similar lines of thinking found in neo-materialism.

This type of modelling focuses on the final entities and describes their properties through a logical analysis of the defining or enduring final shape. Allen presupposes reified generalities in his theorising; a taxonomic approach that suggests an idealist ontology within which there is at least some acceptance of forms and essences that can be categorised and compared to other similar final forms and shapes. A first step in his modelling is to 'construct an initial set of taxonomic rules' (1997, p.4.) or rules of classification of types of socio-economic behaviours. He says that the mechanical model of deterministic equations cannot produce new objects and so 'predictions' are limited to projections of fixed qualitative structures. He goes on to develop explanatory models that describe interactions of components and of different actors and objects. Allen is aware that the actual behaviour of systems does not fit mathematical mechanisms. He recognises that decisions made by individuals are 'not really independent of each other' (1997, p3) and that 'there is an effect of the communication between individuals' on collective behaviour that is not the 'sum of independent, individual responses'. However, his ontology appears to limit what can and can't exist, so he concentrates on ways to simulate the precarious spatial-temporal behaviours of finished products, where the differences of the production process are already cancelled, and the mechanisms of production are not visible.

Allen says a new approach is needed which accepts that people interact and 'that their 'utilities' are linked in a complex co-evolutionary fashion'. I see this as an invitation to apply neo-materialism and specifically assemblage theory to what he wants to achieve in a city development model. This opens the possibility for modelling that would simulate the properties of difference and repetition that result in the final identity of the assemblage. This approach does not attempt to predict the final forms but does allow an additional option of simulating processes where the capacities (parameters) of sub-assemblages can be varied to find how the final properties of a town or city become manifest.

This allows for ontological commitment to transport as a function that can be part of creating novel opportunities for the actualisation of capacities that are not able to be directly seen or measured in

the analysis of the parts that make up an assemblage. By developing a suitable methodology, it may be possible to rank and sort tools of analysis and so make informed judgements about how transport and infrastructure are an influential part of a social material process. The role of transport in this is important and I note that Marvin Harris found that 'truly radical societal change tends to be associated with shifts of infrastructure'. This can come about when the visceral relationship between society and its ecosystem alters in a way that leads to other changes (in the assemblage) in the form of a reconfigured political system, economy, or ideology. The old state of affairs, as cogent to the previous assemblage no longer continues, even if it was considered alright at the time (Harris, 2001).

The expressivity of matter needs to be accounted for in the way that concepts are modelled. Within a model, agency is given to all entities in the world, but at the same time in far more specific terms. This allows the incorporation of the understanding that indigenous and local people have with their environment, with the modernist view of the importance that human innovation and power has in changing the environment. Within modern society some of the material entities that need to be considered as having status and influence in social health are the institutions, clubs, and other social groups as social relations at these levels are important in determining how models reach outcomes that reflect the activity of those assemblages. Each of these entities has a real and contingent existence subject to intensive forces and capacities that affect and are affected by other assemblages. By including non-human actors such as institutions, as actors that have influence, there is a difference in approach to the methodology of modelling the preferences of an individual person as a decision maker, and with society in general. While modelling in this scenario should avoid generalities, and a billiard ball like view of the behaviour of individuals, population thinking can still be useful to look at averaged mathematical populations. What this means is that modelling could be less focussed on making individual agent behaviour and individual choice cellular automata (CA) models, and instead focus on understanding the extensive behaviour of a wider range of actors in the co-production of internal intensive processes, and those in turn are driven by difference. Humans in this context are biological entities within the more general unfolding and flows of matter. In the case of humans, it is flows of flesh that are substantialised and structured upon a mineralised framework (or skeleton) which created levers and mechanisms that means movement is accelerated. Both human movement and the movement of goods or materials need to form part of the history of transport as an action that gets entities close enough to interact. Contemporary studies of the history of human biology where connections between human brain and cultural history are of interest are consistent with this neo-materialist view (Chakrabarty, 2015). While the proposition that human culture emerges primarily through material influences has yet to be fully

developed, see the idea has the possible support for this concept when understood through the observations made of molecular transport systems. The evolution of chemical sentience to neurological consciousness in this context is understandable, historical and has explainable steps, especially if we accept that the brain developed and operates as part of a material environment – that is, the physical world – and not as a distinct organism ‘souly’ within the confines of the cranium. The implications of this is that human social systems contain within their physical makeup non-embodied informational systems as collective expressions of the territorialisation and level of behaviour coding within the entity of a social assemblage.

6.5 Eukaryotic self-governance

It may seem a stretch to jump from thinking about transport as logistics and distribution to considering the evolution of the world, but it seems that both are necessary for creating and maintaining thermodynamic living structures that function far from equilibrium. In chapter five, I gave examples of similitude of transport at many scales and argued that the general process and outcomes for the systems served were similar in both form and function and consistent with the developing transport ontology. For social development, oil powered transport has provided the physical means to extend the reach for trade with much being written about optimising and maximising transport benefits and a globalised economy with concomitant social changes. At the molecular level research in areas of biology, ecology and chemistry can now explain more about the nature of thermodynamic systems, evolution, and the micro world where the phenomenon of transport itself is not questioned but is taken as a given. It is acknowledged as a means of distribution and in cell chemistry it is described in similar terms to the activity of a modern logistics company like Mainfreight or FedEx. What is philosophically significant is that contemporary research about evolution remains focussed on gene frequency and transport hardly features at all.

In Chapter 4 I described how vast communication networks and control systems have been identified in cells. Sigismund et al. (2012) offer a short summary of this: “Endocytosis is the logistics of the cell” and note that the use of logistics in both instances is usefully defined by Wikipedia as “logistics involves the integration of information, transportation, inventory, warehousing, material handling and packaging and security”, and then for completeness they give an even shorter description of Endocytosis as ‘the right thing at the right place, at the right time’ (p273). Those in the logistics industry would recognise this definition as very similar to the concept of IFOTIS, being ‘in full, on time, in spec’. It could well be that the study of multicellular biological systems would well inform research and theorising about which transportation structures and controls would be successful in a world of complex, information rich and fast evolving social systems. There is no

shortage of research that suggests such a reassessment of transport in material usage in social systems is necessary. For example, a simple comparison of the current global footprint of energy materials and resource versus their suggested maximum sustainability level is shown in Figure 37 (Hoekstra & Wiedmann, 2014). In their review of current footprints Hoekstra's and Weidman identify the gap in sustainable practices regarding supply chains should and the resource use of water, energy, materials, and other social consumption footprints. This raises the political situation where supply chains are often disengaged from social governance processes and lack the overall veracity to others allowing the system to 'behave badly' (M. Wilson, 2007). As Bruce Plested, the Chairman of Mainfreight said, transport at a business level reacts and operates within whatever political and economic constraints are set by regulatory bodies.

the growing connectivity of places around the world, questions the suitability of institutional frameworks that govern no more than the narrow interests of transnational profit companies. International connections which are almost topological in their form now complete with regionally based institutions, with the outcome being a direct impact on community structure and health. With regard to this situation Hoekstra and Wiedemann (2014) say that 'ultimately major transformative changes in the global economy are [now] necessary to reduce humanity's environmental footprint to sustainable levels' (2014, p. 1114). The question is not whether the details of their assessments are accurate as the literature is full of similar assessments of the problem and its dimensions (L. R. Brown, 2008; Mark T Brown, Cohen, & Sharlynn, 2016; Daly, 2007; Wells, 2001), but by what means non sustainable usage can be brought back within sustainability limits. This problem is nested within the larger problem of defining what sustainability means in a world of individual choice and free will. The social and moral aspect of this can be disguised as 'a good' as shown when Sachs writes that we are entering the age of sustainable consumption as the world is more interconnected than ever before, and business, ideas and technologies cross borders 'with unprecedented speed and intensity' (Sachs, 2008, 2015). He says that for these reasons these new opportunities and risks mean we have arrived in the 'Age of Sustainable Development', but I find the logic of this argument hard to follow. Sachs relies on innovation and new energy pathways that are based on energy efficiency, as well as farm systems that cause less ecological damage, while at the same time praising modern science for allowing the geometric growth of food production in line with a geometric rise in the world's population. For transport and logistics researchers the growth in the carbon, ecological and materials footprint raises the question about who it is that controls supply chains. The exiting ontology allows for the sovereignty of the consumer and freedom to consume and for authors like Sachs to talk about sustainability without any weight given to energy flows or transportation shows that the material aspect of social systems

falls outside the his world view in which sustainable development is an analytical field of study where the concept consists of a normative framework embracing economic development, social inclusion and environmental sustainability (Sachs, 2015, p. 6) without proposing the imposition of limits on either transport or energy use.

A thermodynamic analysis of a forest ecosystem would expect to find that the system would strive to reduce gradient across a forest by all chemical and physical ways possible. Based on the premise that ecosystems have functions and structures developed to select the most efficient dissipative gradients that support the

forests continued existence. An ecosystem combines physical and chemical components with biotic components with an energy flow from the sun that when combined constitutes a non-equilibrium dissipative process. At a mature stage the density and shape of a forest captures more energy, and has more energy flowing through the system and studies show this to be the case (Holdaway, Sparrow, & Coomes, 2010;

Schneider & Kay, 1994). How these systems remain stable in a way that is consistent with the above premise is central to a practical understanding of transport governance. Within cellular systems there are topological governance systems that manage the interrelationships with the environment.

Could and should a nation prepare for shocks, and in what way? Several transport scenarios have been considered by policy makers with most scenarios not considering the option of no practical and sustainable future for freight transport in its current form. The likelihood of constrained energy supply, waste disposal in the form of CO₂ and a general resource scarcity are not consistent with economic models and predictions and not seriously considered. Robelius has shown that there is a downward trend in the frequency and size of new oil discoveries (2007) and so the problems or limited resources is not a new one. The failure to find new oil stock will impact on freight transport requirements and could significantly reduce transport growth, and new battery centred

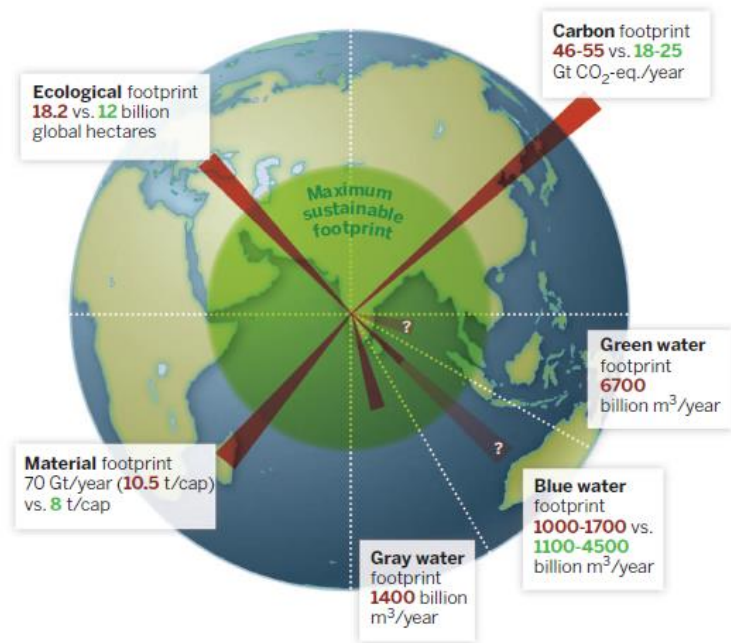


FIGURE 37 FOOTPRINT VS SUSTAINABLE LEVELS

SOURCE: FROM HOEKSTRA & WIEDMANN, 2014

technologies are far from being feasible for goods movement. The significance of a reliance on oil dependent scenarios is that the future for freight transport systems in a limited oil scenario will need to accommodate a reduction in an order of magnitude in freight transport along with all the social challenges that would bring. In terms of assemblages this in turn would create a new analytical framework within which technical education, industrial design, but most importantly town, regional, and inter regional infrastructure. In an extreme expansion of distance¹² time and cost, a return to almost total regional production and consumption could completely change freight transport's purpose and methods. An opportunity here is to plan for limited transport using a methodology stemming from naturalised transport ontology.

A naturalised transport ontology that allows for comparisons of natural systems of different scales and their information system structure offers a novel way to approach transport governance and system sustainability. It opens new epistemic spaces to compare transport system management in cellular and ecological systems can be compared and consideration of the ways that these can be applied to social systems. The ontology opens for consideration any complex systems including household or 'eco' scale that monitor and manage all activities and throughputs as a dynamic process where all parts of the system participate in maintaining the health of all the system. It changes the social scenario from theory based on village-based market activity, as envisaged by Smith who was writing in a pre-industrial time, with no idea that transnational corporations would claim a 'market' status for non-market systems. New ways to model the structure for the survival of the individuals, their families and hierarchical institutions may be better modelled from the way that complex cells and ecological systems have, over their two-billion-year head start in refining transport and control systems design that keep living. This could begin by more clarity and research around the way that cells treat transport, what it is that transport protects, preserves, and provides for individual cells, groups of cells and large beings. The study and comparison would base its presuppositions on natural transport behaviour, entropy as a selection process, thermodynamic flow and physical intelligence as lawfully interacting entities within an ontology of transport and material flow. Social systems are derived from the same evolutionary and hence thermodynamic processes that sustain all living systems, and this allows that a translation into social planning is meaningful and useful for creating future sustainability for human kind.

¹² Take this to be the opposite of the perceived shrinking of distance made possible by abundant and cheap transport energy replaced by high cost and difficulty of maintain long supply chains.

6.6 Intensive processes that change social activity

Viewing transport as a naturalised process enriches an understanding of how real entities are revealed in the world. The processes that lead to the material and measurable properties are the outcome of virtual intensive processes that are largely unseen. We can now take further the idea that while humans can change the world the world also shapes humans by considering how assemblage theory addresses the boundaries and rules of intensive systems. A neo-materialist acceptance of immanent properties that can be affected by countless interactions creates entities with emergent properties that are not just the sum of the parts of the interacting assemblages. The second reason is that the focus on model building needs to be on the attractors and singularities that result in the cancelling of difference in the production of new entities. While Allen (1997) identifies different types of attractors, the importance of their trajectories are not significant inputs into his models, but only descriptors of known mathematical expressions of regularities in their outcomes. The outcome of processes of attractors is the capacities of molecules to actively express properties that create new entities where spatial properties manifest themselves without those molecules having an internal development plan as such. Allen draws a parallel between the activities of molecules and those of individual people in towns and cities deducing that their actions lead to towns and cities as 'undreamed of consequences of the interactions of individuals, at a scale beyond their imagination'. Neo-Materialist can address this in many ways through an understanding of how intensive difference and transport are related.

The modelling of abstract intensities and their result in behaviours and the rate of change in changes in intensities, - that is, how the parameters change could help with understanding system thresholds and bifurcation situations. The term bifurcation suggests an arbitrary change or at least a change of pathways where we picture something that divides. What I propose here is that at critical points of intensity the change is brought about through new and very particular relationship changes within component parts that affect the emergent properties of the whole of the assemblage and specifically leads to an abrupt transition as more than a chance change. Bifurcations understood in this way indicate that a system has changed from the influence of one set of attractors to that of another.

This way of understanding system dynamics has major implications for transport planning. The problem is that the effects transport components can have in assemblages and yet to be manifest assemblages that may or may not be realised are not predictable. This does not rule out some understanding and reasonable assessment of probable outcomes of changing transport processes where there are major similarities to other existing systems as they too are consequential on similar

abstract mechanisms. For example, improvements to urban public transport are known to change land values along the corridor, and that accessibility to transport increases the likelihood of intensive housing development. These are changes in intensity and in material connections as a consequence of 'to be affected' by the role transport has in bringing entities close enough to interact.

An opportunity neo-materialist-based methodology of this type offers is a way to examine the rates of change in system that have identifiable gradients. The higher the transformity difference or difference in the quality of energy or information, the more influential the effects of that sub assemblage will have on the assemblage, or system of interest. The intensive and transformative characteristics of transport mean there are very large gradients across the assemblage of the truck, or ship or train, and so will be of interest. Other measures of intensity include the rate of change of migration, the rate of change of import and export and the rate of change of rainfall. For social processes intensities include the rate of change of employment, energy prices, cost of road maintenance, fertilizer, and the rate of change in subsidisation. Within institutions: medial cover, political pressure, transparency of decision making. Religious control over behaviour is also a coding intensity of interest as an institutional control material. In farming areas, measurable differences in intensities that indicate change include changes in depth of wells, rainfall, fertiliser, or the rate of change of watering systems. The modelling of changing intensities within assemblages where transport brings about a change, provides a high-level input to understanding what brings about changes to the behaviour outputs of processes.

Some guidance as to the influence that components within the assemblage have on emergent properties would come from methodology that sets the outer limits of assemblages of interest. It would need to include how assemblage elements are manifest in the behaviour of the system, and how is this assessed.

Policy that identifies assemblages covering meso level institutions may reduce the problem of unintended consequences by better understanding the intentional actions taken that affect the properties of assemblages. However, this approach becomes very complex as it acts on a continuum of decentralised and centralised decision-making events within each assemblage making it possibly as unworkable as Odum's plan to measure all energy transformations within any structure. This can be addressed through computer simulations with a programming approach that are not primarily rule based but are responsive to continual iterative consolidation and dispersal of materials and information that happen in real time. Again the *a posteriori* emergence of identifiable new entities

means as *a priori* knowledge of what level of agency is the most important cannot include the actual historical production of the event (Leach, 2009).

If it is accepted that assemblages can include both social and natural materials in active interaction, then social groups with a visceral connection to their environment can be expected to have an intuitive idea of how systems will respond to impacts. This could be viewed as an understanding of the immanent properties of the material environment within which they live, where this embeddedness is captured through speech acts that assign limits, give processes a 'spiritual' identity and acknowledge the shape of interactions through symbolic acts. The suggestion here is that indigenous peoples who are very much of, and in their environment have ways of recognising the interplay of material intensities that govern the long-term health of their social assemblages. Fast changes and exogenous impacts to parts of the assemblage of the environment both threaten and change the shape of the governance mechanisms.

What is required if we are to ever understand human systems is an approach that accepts that people interact at many levels, and that their 'utilities' are linked in a complex, co-evolutionary fashion. Allen (1997) approaches this way of analysis where he correctly identifies that an understanding of how structures change requires 'going beyond the mechanical vision of classical science' (1997). Allen's response is to develop nonlinear modelling based on extensive properties where an alternative could be to identify how intensive inputs are iteratively modified to modelling the shape of the intensive processes along mechanism independent paths. Simulations of this sort may need to be more visual or analogical to convey the intensive expression in a way that still linked it to the extensive end form of the simulation.

This would assist understanding of social progress or change not as something that can be accurately predicted, but as guided by changes to current assemblages that are identified as effective in molecular and ecological systems and then to closely monitor change. As the nature of

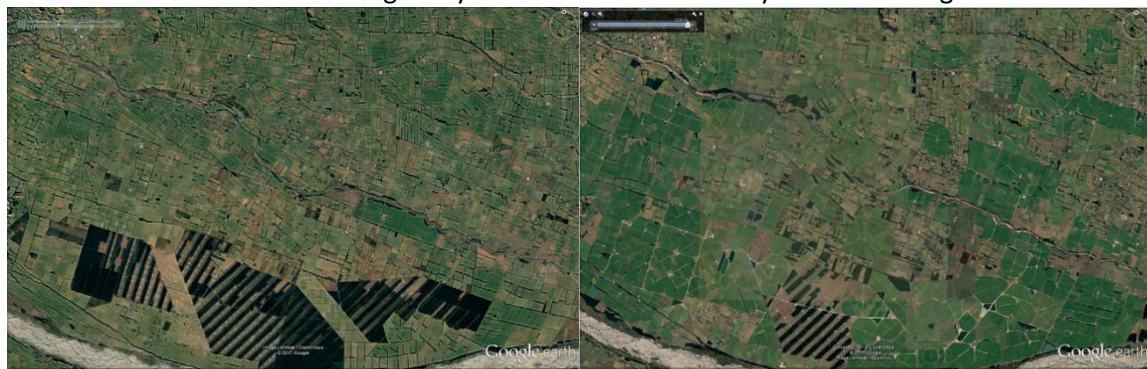


FIGURE 38 CHANGES TO LAND USE IN CANTERBURY NZ. (2000-2016)

SOURCE: GOOGLE EARTH 2018 MAP DATA © 2018 GOOGLE

new assemblages are inherently novel an appropriate level of governance over the rate of change needs to increase, decrease or is stop the rate of change in response to the actual properties that emerge. For example, the control over the development on intensive dairying on the Canterbury plains would require active control of increases in fertiliser, water use and power within the assemblage of the system. As new properties emerge, alterations could be gradually made over decades or century's, depending on the capacity to be impacted of the farm. A simple example of intensive change is given in Figure 38 Changes to land use in Canterbury NZ. (2000-2016). The changes through dairy development are expressed through the difference in the land use evident in these images. Changes of intensities then can be expressed metaphorically of visually. Through careful and incremental changes to the parameters of key assemblages, emergence develops as interaction that coaxes out form and structure though interaction that is aesthetically pleasing.

6.7 Chapter summary

Social materials such as towns, cities and nations are products of assemblage processes created over time and through material processes that include transportation. Each entity is maintained by processes of feed forward and feedback between and within assemblages. The physical information of material system, along with energy and matter are part of the fabrication of physical entities of the world. I have argued that real entities such as families, towns and countries are produced by real and historically situated processes that are contingent in the maintenance of energy flow through those assemblages. I have argued that the capacity for components to be analysed and to be observable and measurable by humans can be done with all entities having the one ontological status. This is evidenced in the existence of living things with a level of complexity and maturity attained millions of years before the first human lit a cigarette.

I have shown that a new transport ontology identifies the things in the world that provide a scientific explanation for the commonality of transport processes at many scales of living systems. I have looked for comparisons and analogies where the likeness is more than superficial and have definable attributes that are consistent within a transport ontology. What is exciting is that researchers working in fields as varied as social ontology, physics, biology, and ecology are all identifying, discussing, and describing transport phenomena in terms that are interchangeable with the parlance of modern humanly operated logistics systems. This indicates a surprise/no surprise continuum where the surprise is finding transport and communication activities not previously within the area of consideration. The 'no surprise' findings, if the ontology is accepted, including the concept of abstract but real design is that transport and supply chain terminology can also be applied to transport processes.

As established in chapters three and four, a separation of human experience from the material experiences of the world provides a deeply divided response to the question of 'what is in the world' through separating man from nature, and the living from the non-living. With neo classical economics, the separation continues in a modified way, with economic ideology separating economics from questions of social structure and reducing the human to that of a consumer. Neo Darwinism, with its narrow focus on selection via genetic information and the general concept of the survival of the fittest serves to reinforce and maintain the chasm between the world as an alien and hostile place and man as knower and organizer, but now goes further and differentiates the consumer from the socially complex and self-other sustaining responsibilities of citizenship. As a result, much of our social structure acquiesces to the influences of messages from those who control global economic activity. That control is largely dependent on transportation satisfying consumer demand without full information on how energy flow affects survival. Offer argues for mechanisms that control energy release, or for resource usage to be controlled at a rate that can optimize the evolutionary good of the system (Offer, 2006).

Cooley recognised the change in signifying transport purpose away from its role in maintaining social good as the economy of his time underwent cultural changes. He wrote that the rise of classical economics was marginalising the physical world with transportation moving toward being considered exclusively as an economic function and a subject of engineering science (Cooley, 1894, p. 61). This is further reinforced by Rodrigues's description of the status of transportation covered in Chapter 2. Cooley maintained that transport decisions need to be made within social frameworks and functions where the responsibility resides with socio-political institutions to govern the transport function to protect the health of social systems. This view has similarities with the hierarchical power structure that Odum found in ecological systems. It is therefore more correct to say that modern innovative logistics and transportation systems resemble transport in cellular systems and not the other way around. This suggests that a different way of looking at transport offers a mechanism to develop sustainability.

Chapter 7

Methodology, Examples with explanations

Modern war is so expensive that we feel trade to be a better avenue to plunder.

(James, 1910)

The laws expressing the relations between energy and matter are not solely of importance in pure science. They necessarily come first...in the whole record of human experience, and they control, in the last resort, the rise and fall of political systems, the freedom or bondage of nations, the movements of commerce and industry, the origin of wealthy and poverty and the general physical welfare of the race. If this has been too imperfectly recognised in the past, there is no excuse, now that these physical laws have become incorporated into everyday habit of thought, for neglecting to consider them first in questions relating to the future.

(Soddy, 1912 in Foley & Nassim, 1976).

7.1 Introduction

In this chapter I give examples of how transport ontology can be used to inform transport theory, research programmes and social governance and give examples of how this can happen. I argue there is a need to change the way that transport projects are theorised by placing more focus on the intensities within systems and less on the analysis the metrics of the end results of development and change. The second part of the chapter considers examples that illustrate how transport ontology can inform modelling processes. I discuss what could be done to increase the intensities in to models and discuss how to set the boundaries and scope of modelling.

This chapter addresses how realist ontology and neo materialist philosophy can inform social planning of how theory developed from transport ontology is likely to influence changes to communities and countries. This is done by identifying the determinants of transport changes within existing assemblages and describing or mapping assemblage changes that follow. Key material entities and institutions are identified, and the role of the history of the individual entities features here. Parameters for this analysis are drawn from the findings of chapters five and six. In this chapter I use the word 'project' to mean any human instigated change where transportation has an impact, which given my approach to transport ontology covers virtually everything.

7.2 Methodology consistent with my transport ontology

“What avenues of enquiry are opened up? What questions are made possible by thinking through social and material formations as assemblages?”

(Allen, 2011, p. 154).

A naturalised transport methodology can be used to change the emergent effects of an entity by altering a transportation process of some kind. Methodology that is consistent with naturalised transport ontology, especially one that can be applied to research within social systems, needs to focus on how the power and influence of transport acts within an assemblage that is the focus of any project. Following my arguments for more focus on the immanent properties of materials and intensive thresholds, measures of transport and what is transported need to be made with a methodology that works with intensive properties. The focus here is on systems that are far from equilibrium where bifurcation could lead to new assemblages with different properties. To understand a system in this way requires some knowledge of its historical coming into being, so we can understand its current dynamical state (DeLanda, 1997).

As already shown assemblage thinking includes an understanding that materials combine in the specific features of a new entity. Some parts of assemblages have small or predictable influences and don't need to be torn apart or over explained. Other parts have feedback potential of many powers and greatly change the emergent properties of an assemblage. Charting and tracking the intensiveness and expressivity helps understand how processes of intensity act to create material objects within which those processes are hidden becomes part of a methodology, along with the need to gain an understanding of how historical material interactions expressed themselves. The quality of the specific type of energy is the most significant factor in how living systems develop. Transport within a system becomes the enabler of this flow of energy-matter, and the constituent changes to assemblages. Methodology in this context needs to recognise and analyse the presence, history, and intensity of this characteristic of transport. That the most significant factor in assemblage properties is the change intensive difference in energy flows. Naturalised transport ontology accepts that wholes, with their own properties continue to perform as wholes within assemblages for which they are also parts. This means that when a change is made to any part of an assemblage, the 'output' of that whole changes how it affects as a part of other assemblages. I have identified that this creates novelty.

A challenge for modelling future possibility is to understand significant changes within significant assemblages, and to understand that it is from here that new assemblages exhibiting novel

capacities and tendencies will arise. It is an instinctive probing of possibility space and a revision of roles in processes of complexity and situations of power. Human minds are situated within the blind probing of possibility space and are at the same time exercising physical influences on flows of materials, relying on known differences that already manifest themselves in energy flows.

Using historical examples of how similar assemblages expressed their properties means we can learn about the shape of possibility space by a comparative approach. A methodology that includes explanations of past events offers the opportunity to discover the architecture of processes and so identify the drivers of the main causes of the differences in outcomes between different places.

A way to understand the abstract processes has already been pioneered in Odum's systems diagrams. DeLanda also endorses this method of communicating and understanding how self-stimulating processes, feedback and active material processes can be combined. The level of self-stimulation may depend upon the strength of a hierarchy. A methodology needs to address how dominant the different decision-making processes are within an assemblage and whether the structure is centralised or decentralised in its makeup.

The presence of natural intelligence as part of perception and feedback systems and their role in guiding activity in the maintenance of the cell needs to be addressed. The physical information flowing through all systems and specifically complex systems with physical intelligence contain regulating controls akin to human thinking, with at least something that regulates activities that ensure their persistence as a physical entity. There are regulation systems in prokaryotic and eukaryotic cells just as there is regulation in forest climax systems and this suggests that similar mechanisms of regulation can be expected to be found in social systems that govern flow in and out of economies and households operating at multiple institutional levels. This approach offers ways to experiment and understand the characteristics of assemblages by looking at similar structures of other types and scale. The timescale of change and development need to be considered. The need or criticality of regulating mechanisms in system that took billions of years to develop may not at first be appreciated with human social systems where time is segmented into months and years.

LeCain (2015) offers four principles and methods that help ground neo-materialist thinking. He says the material environment needs to be understood as a single unit of the technological and natural. This implies assemblages as "Humans and their machines, houses, cars and factories do not inhabit, destroy or impinge upon a separate natural environment; rather, these human-associated artefacts fuse with non-human nature to constitute the unitary material environment in which we live" p27. This situates our social world as a subset of our material world, and not separate from it. Baker and

McGuirk (2017) identify four common commitments found in a review of a range of assemblage thinking projects. They are 'commitments to revealing multiplicity, processuality, labour and uncertainty'. Baker and McGuirk say that methodology needs to reflect a process of 'arranging, organising and fitting together' and how this happens. Assemblage processes are only ever temporary, and relations may change constantly so opening new lines of flight, making it is a view of the world that is emergent and in flux. They say that 'processes and practices come together to render their (never pre-determined) effects' (2017, p. 431). Following from the ontological commitments made in Chapter 5 and then applying them with the methodological guidance of LeCain and Baker & McGuirk outlines a path for a new methodology for transport.

Within neo-materialist thinking there is a view that the natural and the technical are part of the one unitary environment continuum. This requires a non-anthropocentric stance where humans are there as the production of matter, and that the 'sociocultural emerges from and is embedded in the material world' (LeCain, 2013, p. 29). Understanding the world this way puts a focus on the material history of things as it captures the 'dynamic, agentic and emergent capacity of the material environment' (2013, p.28), where geology processes lead to the creation of culture. The separation of the sociocultural and the material can be challenged, where the 'social is not only a product of the material but contiguous with the material' (2013, p.28).

The outcomes of any given situation then are not linear and cannot be predetermined and so it is important to avoid imposing on them rigid explanatory frameworks. There are labours of 'putting together' and 'arrangement' that come together and come apart. The agency of labour is distributed across dynamic formations of humans and materials. In this context theorists are not distant observers, but 'embedded translators' of the immanent processes and ever-changing assemblages.

Methodology of this kind can be used to gain a better insight into the understanding of transport. Historically we see transport's effect on culture captured by the observation that the first steam powered engine in 1830 changed the culture everywhere in the world (Atkinson, 2007, p. 10). Similarly, technology of energy extraction from coal reshaped assemblages that gain power from a thermal gradient. Given that difference in gradients are a universal of all thermodynamic material assemblages, it is almost inevitable that all things change when thermal gradients change.

In analysing the way that railways changed the world we can look at a number of those intensity differences that have the highest capacity to affect. The introduction of hydrocarbon engines, firstly coal then oil fuelled had a large impact on rail transport. Before that rail carriages were powered by

horses as was the case with New Zealand's first railway from the Dunn Mountain mine to Nelson, or in Australia's case – powered by the manual labour of convicts. The development of cotton mills relied upon harnessing the power of hydrocarbon energy, but the machinery also needed the variant of long fibred cotton that was being cultured at the time. There were already cities and cultural differences caused by an earlier topological change where sailing ships connected distant towns, and towns from different countries at a time scale much faster than that of land-based transport.

The topological change also affected the mass of things. Large volumes of material, such as coal could be transported at a fraction of cost and at in much less time over land distances previously not negotiable. The power output changed the parameters that defined what work means in a social setting and in the complexification of material structures. Within transporting engines, the intensive differences being exploited is the huge pressure gradient available through converting the concentrated energy of coal into work while on the move. That intensity became available to existing material structures such as railways, and the conversion of pathways previously only used by carts or drays.

Situating transport as part of expressive and vibrant material processes requires that past separation in theorising between social and material space be modified. By taking a different methodological approach to this where the focus is on the agencement, the assembling and reassembling of all kinds of material wholes – whether institutions or geological intrusions – can inform how transport systems inform the emergence of future novel assemblages. Once an assemblage is optimised it stops changing, or at least remains the ongoing selected entity under similar conditions. This does not mean that there is only one ultimate assemblage (for example a eukaryotic cell), but that within that environment that contingent structure is the one that interacts with the environment. For example, taking material of high energy transformity into a system of lower transformity will act as a positive feedback loop and increase the overall intensity of production. Identify the input assemblages of large influential assemblages and be prepared to research the history of how something came into being. Map likely lines of intensive differences. A historical assessment of biocentrism requires the serious consideration of the creative role of local and global biogeochemical cycle.

A methodology could be developed that includes ways to identify gradients and investigate them as places where there is the production of difference. Their steepness, the quality of the energy and power are a measure of the intensive forces cancelling within the project. As found by Odum, higher levels of transformity create the potential for larger effects on systems in both time scale of events

and magnitude. A priori techniques lack the ability to predict the outcomes of changes in assemblages where novelty entities then act to change those assemblages as they are processes of emergence where the focus needs to be on understanding the abstract architecture of change agents.

As the exterior and final properties of the finished entity are not representative of the internal processes it is necessary to map feedback architectures that have been at play to identify the direction and effect of the non-linear processes. The more quadratic the intensity of the feedback is the larger the intensity of the effect. Because nonlinear systems allow small causes to have large effects and large effect so have small effects and understanding of the motive roles of intensities and singular points of attraction become significant. An aspect of this type of methodology would be that it examines how progress is affected by the reformation of assemblages, by not relying on predictive tools but instead measuring incremental material change at a stage where affects are easy to detect and easily countered should there be unforeseen consequences to a change. Feedback processes influence the nature of the change by amplifying the effects of immanent properties that are changing. Where transport systems are part of an indigenous material environment this process can be followed by listening and looking at the way local knowledge in all its different forms manifests adaptive behaviours to increase positive flows of social and cultural materials. A materialist processual evolution progresses via this instinctive probing of the possibility space. In this context culture is an aspect of a connection to the material world's innate expressivity where the methodology employed accepts that assemblages are entanglements of many material flows and expresses culture in connection with material world from which it emerges.

Once the expressivity of matter is included as real interactions between matter in the environment that influences the shape of human culture it opens ways to describe and document the activity the expressivity of key assemblages. Because the future is open and not limited to what we can understand by examining the parts of the system that are about to interact in a new assemblage the process becomes one of an unfolding nature. This allows the cultural effects of high energy inputs to be identified to reassess the way we include material structures in actions that influence human society.

Many of the world system assemblages now have human created parts. The weather system has thermal energy added to it from the infrastructure of settlements and the emissions of vehicles. Weather is no longer an inanimate, isolated system, but is one connected to oil wells, and a billion machines that exhale thermal commotion into the atmosphere. "there are now so many of us

cutting down so many trees and burning so many billions of tons of fossil fuels that we have indeed become geological agents. We have changed the chemistry of our atmosphere". (Oreskes, p93).

7.3 Canterbury plains and intensive change

This section gives examples of how and where natural transport ontology and subsequent methodology can be applied to human farming system. At a large scale geographical level flows of heat in the earth cause the Earth's crust to move and result in the up thrust of mountains, with the Southern Alps of New Zealand being a stunning example. Water flows downwards off the Alps leading to the formation of streams and then rivers that transport materials onto flood plains, and the rain that caused the flows was itself caused by the rising up of warm air over the Alps to create that precipitation.

The activity of farming is a defined and segmented space within which intensive energy flows produce products of higher energy quality. Fencing and controls over gateways offer ways to maintain higher energy flow opportunities. To satisfy the second law of thermodynamics, the maintenance of such a place of low entropy requires commensurately higher flows of waste energy into the surrounding environment. It is reasonable to say that the surrounding environment has historically adapted to energy flows known to be present before there were farms. A baseline energy flow could be theoretically established by considering the same space as a non-farmed environment, where energy flow is seasonal, at an intensity that results in stable ecosystems over millennia.

The act of farming is a modification of an environment through focussing on activities that create more complex entities than occur without those intensive processes. This may be by fencing an area to increase livestock numbers per unit area, by planting trees to create wind breaks that remove heat and drying stresses on plants and so allow more of their energy to go into biomass growth, or to control grazing in ways that create 'pulsing' feeding strategies to increase the biomass of animals. The intensification of flow behaviours create systematic opportunities to complexify where those flows act back upon the system in non-linear ways to create new or novel non-predictable structures and at a certain intensity of activity a bifurcation within the assemblage of that environment.

To gain a net energy yield through farming relies on harnessing large quantities of energy flow at one quality level flowing through the system where there is a capacity to be affected by it. The affect for example could be the uptake and transformation of energy by plants that photosynthesise. The informational entity (the plant) that has the capacity to be affected has an

endogenous molecular informational system with sentient nonlinear feedback processes that act on the incoming energy to create more complexity that in turn acts back within the process as a control or to accelerate food inflow. The exact mechanisms of this autocatakinetic (circularly causal relations driven by entropy as a directional force) process are still being discovered and currently are only generally understood. What is postulated however is that their *modus operandi* is characterised by physical interaction with other living entities in their environment that result in energy powered informationally driven molecular changes to material structures which include sophisticated natural transport processes. The result of this process is that from a large quantity of energy flow at one level of quality structures acts on the materials present to produce a small quantity of higher quality informational matter (ribosomal transformation) at the next level. Grass from sunlight is an example at one level, and animals from grass at another.

For a flow processing entity, such as a cow, to be a material object of complexity and persisting far from equilibrium requires a constant stream of energy flow through the system where 100 units of energy at one level are processed by the cow in this case to create one unit of energy at the next level. Immediately it can be seen that a zone of intensity like a cow creates huge flows of energy flow 'to waste' and this level of energy quality heat loss occurs at every level'¹³.

Consequently, it can be surmised that by spatially intensifying energy flow through farming practices and changing the nature of fluctuations there will be an exponential change to the amount of 'degraded' energy flowing from a set area of farmland. In short, the intensification of flows creates more waste flows as intensification, like the complexification gained through economic growth) is coupled to energy flow and waste energy production as this is required to sustain entities far from equilibrium.

The flow of entropy is such that high quality energy always takes the most direct path available to it towards a high entropy state and complex structure where present offers a faster pathway, so complex structures create entropy faster than simple structures and are chosen within the constraints of the system. As covered in earlier chapters Swenson considers the significance of this to be at the level of a nomological law influential enough in the structural processes of autocatakinetic systems to be proposed by Swenson as the 4th Law of Thermodynamics (Swenson, 1997). It is a very non-Boltzmann view, and further develops upon Prigogine's exploration of

¹³ For work on the quantification of energy flows and flows to 'waste' see Howard Odum's description of power in ecological systems and the effects of human intervention (Odum, 1971, Chapters 3&4.).

persistent far from equilibrium systems and the increases in possible historical outcomes (DeLanda, 1997).

Following DeLanda's (1997) theorisation of this process in order, to understand this system one needs to understand the historical process of intensification and bifurcation that leads to the accumulative adapted traits that led to the focus of study. In this case it is the actual cows (not cows in general or reference to an ideal cow), and the specific nature of the land underneath, and that actual farmer that combine to create the particular assemblage. Consequently, every one of the current 1.4 billion cows have historical traceability back to a single herd of about 80 animals in Turkey 10,500 years ago. Each cow also has a personality that affects their grazing habits and use of energy and helps to structure the way the 'table is set' (grazing pastures and types allocated) by the farmer for the cows' use (Gregorini et al. 2017). This is based on the historical knowledge of the cow and its personality.

Likewise, there is a similar historical understanding of how that land called Canterbury plains came to be, not just a reified idea of 'land in general'. The way the land is farmed would benefit from analysis and a short history of who came to farm in Canterbury, what production and farming techniques they brought with them as well as what sort of animals they selected, and how they view their relationship with the land they now occupy. This would help with an understanding of how decisions are made, and how farmers react and interact with institutions and the way the relationship impacts on the land use. It would lead to an understanding of the incentive to produce milk in this location.

Cows are domesticated ungulates orbovidae, from the general class of large mammals that included horses, pigs, and giraffes. They sustain their whole-body weight on their 'toes' named hoofs when they walk. They are adapted to eat poorly digestible food such as grass cellulose through specialised bacteria and rumination processes that enable large quantities of feed to be ingested and subsequently processed at leisure. They have been like that for 10,000 years since domestication from wild aurochs. A genetic study traces all cows to a single domestic herd of wild ox and since that time there has been selective breeding for traits that suit a certain type of farmer and farming space.

The farmer is situated in a certain landscape space at a certain time for the benefit of the farmer in a specific chronological, physical, economic, and social space. The farmer brings to that space individual cows whose history began through a certain intensifying act. Traditional farming balances intensification within natural energy flows with transport and social factors shaping the quantity.

The farming strategy, crop choice and animal choice are in relation to direct needs, and the fit with the environment and energy flow.

What we know is that each farm is an assemblage with unique properties arising from how a cow is selectively bred for improvements in economic value through milk, meat, and leather, and how it is farmed for the benefit of each individual farmer in each specific farm space. Cattle in New Zealand are predominantly bred for high milk output, requiring them to calve annually. Historically and in other social settings there have been other farmer goals in having cows as they have also been held as capital, or chattel, hence the name 'cattle'. Cattle is a word that once represented movable property, while now cattle are somewhat stationary and fenced to reduce any activity other than feeding.

The Canterbury plains also have a history and within the area of 'the plains' each river system flow has a history, with a time when there was no flow and there was no land. The plains are the result of a geological upheaval creating the Southern Alps, and several consequential energy flows and climatic conditions created or influenced by that event. What resulted are the material distributions in river systems and through airflows bringing dust and water to that space.

Historically the Canterbury plains have a specific start point, or birth as an entity as the result of specific geological processes. In geological time the plains are considered very young, and would exhibit very active material distribution processes should the activity over the last 10,000 years be condensed into a five-minute film, for example. The system continues to be a flowing process as the water in the rivers we see, and in the aquifers that we know to be underground. As transport systems they provide the constant transport of gravel, dust, and rainfall modifications. A main driver of these flows is the intensive difference in air pressures leading to precipitation in the river system head waters, and dry hot winds blowing from the north west.

Within this system we see alluvial gravels, braided rivers, and loess deposits. Norwest airflows mean that the ongoing deposit of soils continue. We know that water from the Alps flows downward to aquifers and outward to the coast. The ground under any intensified farm also has a particular and specific history resulting in a certain soil and water holding capacity that is changing in geological time, and its current condition is contingent on when it was last river channel, how the wind deposits soil, how much rain happens.

In their natural state streams and rivers from the mountains are mainly oligotrophic with little nutrient loading, significant turbulence and only a light loading of nitrification owing to ecological processes and a little ponding as water percolates through the gravels and enters aquifers. Water

from those aquifers continues to flow towards the sea, surfacing generally a little to the left (when traveling south) of SH1 as springs and streams. Again, this is an historical flow process with a surface, aerial and subterranean topography that serves to maximise the rate of dissipation of energy in the water.

Everything about the topology – processes of convergence, compactness, and continuity - of the Canterbury plains can be explained as the result of maximised energy dissipation within the given material constraints of the system and so the description is consistent with Swenson's view that dissipative flows create islands of structure with low entropy relative to the surrounding conditions. Tussock is a prime example of this, where its complexity then traps airborne nutrient laden dust and feeds back this energy source to create soil.

When we bring together the physical and belief systems through processes of intensive settlement and transport we set the scene for several systems' changes that impact on the natural environment. In his systems architecture diagrams, Odum identifies three flows that create complex energy intensifying systems. There is energy that is used to sustain the production processes of the entity, energy that feeds back energy to increase inputs and some of the produced higher quality energy that feeds forward to produce quality energy products such as milk and meat. Odum describes the workings of the abstract architecture of the overall autocatalytic process as 'tripartite altruism' and this is what we see in farming systems. Animals bred for milk volume production are intensively farmed on the still developing alluvial plain characterised by the material build-up of waterborne rock, and air borne soil from the up thrust Southern Alp, by farmers creating zones of complexity known as a farm.

Farmers and farm support structures are themselves flow entities enabled by transportation and an economic system of exchange. To maximise output (and concurrently waste flows) farming intensification requires maximum water and feed inputs. As ruminants are processors of grass, the rate of grass input can be boosted by growing more grass in a fixed area and supplementing the energy content through feed supplements. Maximised lactation is achieved through maximum feed in (pulse consumption) of land, and a mix of minimum animal energy used in fighting disease (antibiotic control of health), restricted energy used for covering distance (fenced grazing), protection from predators and parasites (fencing and chemical controls). This results in a change in intensities, in (for example) the relationship between land, animal and consumption that result in new and different properties that didn't exist before intensification. The term 'intensity' as used here refers to changes of pressures and flows of any matter that has the capacity to alter the properties of an entity. Consequently, there is an enhanced likelihood of bifurcation and changes in

'phase space' might occur. An example of how intensity changes the properties of an entity is the phase change that comes about when a horse changes from walking, to trotting to cantering. At a specific incremental change of speed, the entire movement form changes. Farming intensification results in changes to fast flowing turbulent rivers that move materials and so remain oligotrophic as they are slowed by water moving in laminar flow in canals and pipes. Dykes, banks, and extraction change the natural flood plain fluctuations of water and nutrient dispersion. The water now passes through ruminants and is dissipated over space in a different way before being returned to the ground laden with nutrients and solid matter, where it moves to a non-autotrophic via non-turbulent flow creating an altered, non-oligotrophic food web with the capacity to offer luxurious or unbalance growth conditions (Williamson, Close, Leonard, Webber, & Lin, 2012). Here there is a change in subterranean energy flow intensity.

The ecosystem of interest here is a bio space between grass and aquifer; a groundwater ecosystem, that is a living heterotrophic ecosystem modifying what is an historically developed porous surface with low ground compression, (i.e., porous, low density sediment on gravel filtration) filtering rain water and periodic flood events from oligotrophic flow systems. Could different forms of complexity develop in these porous structures to the extent that waste flows from them enter aquifers and survive? Williams et al, (2012, p690) consider that heterotrophic biofilms can get established and affect 'this unseen and largely unknown ecosystem and in ways that have yet to be predicted'.

The questions of exploration of this new space includes understanding the kinds of dynamical feedback systems interaction can there be between the three actors of interest? To recap, those actors are the flow structures of the Canterbury plains, as they are now, and being the result of thermodynamic and geological pressures over their fixed history. The cattle brought to this place with the objective to maximise milk production, the flow structures of each farmer, who brings to the space or has access to historical knowledge of how to farm exercised via increasing input energy flows by bringing to the farm space fertilisers, feeds, antibiotics, and water that would otherwise not be on that piece of land.

What is apparent is that this concatenation of intensive milk production on quaternary moraine gravels (the conjunction) creates novel energy flow intensities that have the capacity to bifurcate the current water flow and ecosystem performance where certain conditions occur. The conjunction radically changes energy flows on and through the surface and subterranean filtrate media. The ground water biofilm dynamics of the Subterranean Alluvial Nutrient Ecosystem (SANE) is likely to change. A result of this could be that such groundwater ecosystems could create outputs that degrade water quality in streams and aquifers.

A response that has a focus on gaining an understanding the abstract architecture of the systems would be to monitor the condition of the SANE to discover what is happening in this ecosystem as there is a chance that toxic biofilms could potentially become established as huge anaerobic systems that alter, block, or destroy the natural filtration systems. Concurrently, the affect that hoofed animals that act as land compactors may create a non-permeable filter mat preventing existing processes and creating new and different flow processes. It is recorded for example that the introduction of sheep in parts of Australia had the effect of compressing the ground and changing the ecosystem by stopping the growth of certain aboriginal food crops. The uniqueness of each assemblage is important, as studies have also shown that some hoofed animals – e.g. horse hooves cut up turf mats over sand dunes and cause more degradation than trail bikes that had been thought to be the culprit – again reinforcing the unique way that parts of assemblages interact. Should intensive animal grazing change the permeability, then highly eutrophic water run off could shock impact streams and waterways creating changes to water quality in other than aquifer storages.

For policy makers a neo-materialist derived methodology needs to factor in the possibility of phase changes that could occur through increasing energy flow inputs the system becomes subject to bifurcation and grand scale environmental change. Given the high exhaust loading from intensification, it is the exhaust environment that is at risk. A constant water flow and animal excrement flow onto alluvial SANE will change the subterranean system at a certain point. Changing the intensity of inputs to a farm that has historically selectively developed the capacity to process waste flows based on lower, or different intensities will result in a new assemblage with new properties that cannot be predicted. A way to understand the conjunction, and what would indicate that the overall system is coping or not would be to consider the following:

- Compression changes to farm surfaces to measure changes to the expressivity of the land
- Core sample analysis of SANE communities to identify the output of assemblages
- Sampling of post rain event flood channels
- Turbulence monitoring of changes in the capacity of the river to grind up rocks, change channels, flood and transport sufficient silt and waste.

It is possible that there is no waste treatment process suitable to prevent the destruction of the SANE assemblage. A top down decision to limit irrigation and prevent nutrient addition and the consequent diversification of the land are probably the starting point.

What I have done in this example is to base my analysis of farming systems on the Canterbury plains around the changes of intensity in assemblages. It identifies that changes in the intensity of water,

nutrients and methods change the properties of the material system. The analysis process identified the importance of the subterranean ecosystem assemblage, bringing it into the overall system equation as an active part of energy flow. Whereas gravel beds are often thought of as inert systems that allow water to drain through them, analysis using presuppositions from naturalised transport ontology raises awareness of the active assemblage of subterranean matter.

The description is enriched by historical details of material changes in landform, the selective processes that led to the types of animals being forms and includes historical and social history of individual farmers and social assemblages. The example also highlights the multi-varied aspects of transport within and between assemblages. The processes that enable the transport of materials is central to the rapid development of Canterbury Plains farming assemblages.

The role of transport in every part of this example is that intensive farming uses transport to bring materials together without knowing how the new assemblages will interact under the intensities of the system. The new or innate properties of introduced or intensified materials act upon the abstract architecture of the system and may move it outside of its possibility space and so bifurcate into a new system that exhibits different abstract architecture. In doing this the material world then acts back upon other parts of the system, and may modify the behaviour and actions of animals and inhabitants of the environment, including those of the farmer. The active interaction between all parts of the environment play out over time until selective pressures ensure persistence of the most viable assemblage in those actual conditions. Because transport brings new materials close enough to interact it is a major determinant of how fast changes occur.

7.4 Hydrocarbon powered rail transport

When human society accessed the difference that burning high energy hydrocarbon brings to assemblages, a huge change came to what materials could manifest within social systems. As an example of the application of transport ontology within social systems, I consider how the energy gradient gained by coal powered steam engines influenced social structure where 'man has changed the world, and the world has changed man – in a very short time indeed' (Girard, 1965).

The development of steam powered railway offers an historical case study open with which to test out a neo-materialism explanation of that development. The following critique shows how such an interpretation is rich in commitments to things in the world that align with a realist transport ontology. At an overview level the importance of steam powered railway is a general consensus among rail historians that steam powered railway changed the world (Atkinson, 2007; Faith, 2014). It is possible through a railways case study to show how a socio-technical invention affects most

people in most countries, and changes culture, and social processes using a new materialist explanation. The purpose of this example is to show that the embedding of rail technology within social progress, via the release and capture of the heat gradient within coal, drove social and cultural change in a direction generally consistent with flows and processes found at cellular, and ecological levels.

Railway travel as generally understood today did not start with Stephenson's trialling of an invention capable of loco-motion. Before Stephenson developed his steam engine, rail-ways had been in use for hundreds of years in the form of horse drawn carts that provided the motive for carting, for example coal from mine to canal (Faith, 2014, p. 8). Neither did Stephenson's invention change everything immediately, as horse drawn cartage continued to be viable within mines, and for mining operations such as the horse drawn tram way Dun mountain railway in Nelson up until 1901. It is interesting that canal building also continued concurrently and in many places at a faster rate than the expansion of railway tracks.

Experimentation by engineers with machines that could exploit pressures difference to drive processes of work began with the first known steam engine for industrial use built by Savery and patented in 1698 and used for pumping water out of mines. The development of this engine was the culmination of both steam pump and steam turbine development beginning with Heron of Alexandria's Aeolipile in the first century (AD) in Roman Egypt, and mechanical development and exploration, a form of human blind probing. Development, continued through to basic steam turbines or mills, later known as steam jacks, capable of doing work such as operating pestles and mortars milling apparatus in the 16th century. What Stephenson's contribution enabled was identify a new capacity and application for stationary engine technology that had been in use for years in mine pumping stations, cable haulage incline railways, boat lifts in canals and of course in cotton and flour mills and reassembles it. He created an assemblage that drew together rail, stationary engine, and a cart in a novel way. It was a variation on an already developed transport mode and it is interesting to note that the first railway designed for steam traction, the Stockton & Darlington Railway (S&D) also had the capacity to use an assemblage of horse and wagon on the rail bed.

At an operational level Atkinson describes a railway system as a 'machine assemblage' of 'timetables, station clocks signals and lights, tablet systems and Centralised Traffic Control' (Atkinson, 2007). This is an extraordinarily close description of the machinic assemblage of transport apparatus discussed in chapter 4 as found within a cell. Atkinson continues his description of a rail (machine) assemblage as enmeshed in a web of bureaucratic control, symbolised by its meticulous timekeeping and military-style hierarchies, discipline, and uniforms'. That is, it challenges the idea of

a paradigm shift as a complete sea change of non-sequential innovation pathways, where both small or large changes to parts of an existing assemblage create new entities with new properties and are characteristic that are central to new materialist thinking. Previous rail ways had been exclusively horse drawn with the rail concept now folding into an assemblage that supported other motive power. Part of that 'folding' was very real and material, where metallurgical folding produced flexible iron rails to replace non-malleable wrought-iron ones. Here we see the abstract architecture of folding and strata-forming resulting in the producing of new material for rail development. The architecture of stratification and folding are an example of a double articulation found extensively in material processes including the mountain ranges of the Kaikoura coast found in the case study about this below.

In reviewing the historical development of the railway system associated with Stephenson, Faith (2014) concludes that he 'did not originate the steam locomotive, he did not invent a new type of machine; but he used other people's inventions and improved them so completely as to make them peculiarly his own' (p10). Just as railways have historical routes, long distance rail is an historical forebear of a non-rail dependent transport system collectively called globalisation. In this context Brunel's influence in building rail access from London to Bristol is matched by his vision of intercontinental transport from London, via train to Bristol, then by sailing ship across the north Atlantic using his dual powered steamship called the *Great Western* (23). The expansion of the 'iron web' (43) itself portends other transport and communication web based on similar abstract architecture through the capacity to affect and be affected made accessible by steam powered rails ability to get materials close enough to interact.

Stephenson increased rail efficiency by modifying the wheels of the carriages by adding flanges that could run on edged rails. In describing this change. Faith refers to a French account at the time where he said of the new assemblage, 'the railroad and its carriage should be considered one machine'. This acknowledgement of the rail system as an assemblage of different entities is quite insightful. Faith (p12) notes that the Stockton & Darlington line was not the product of technical innovation, but the achievement was the assembling of something new, from current and existing successful activities, and to create the new relations of externality in a way that produced the novelty it afforded, even if the scope of its use was limited to passenger transport and coal on a mine to port route.

The changes in rail-based transport came about for Stephenson because he worked with a concentrated combination of mines, rail-ways, and capital, and associated with colleagues from whom he draws on for their experience. This combination provides a field or possibility space of

heightened intensity consistent with neo-materialist characteristics of the emergence of new entities. In making this point Faith (2014, p10) writes that “he was backed by both the money and skill to assemble the package – engine, wheels, track – required to make steam locomotion an economic proposition.” What Faith describes here can be understood as an assemblage, where the total package – the novelty or new entity - has emergent properties not found in the parts. The assemblage Faith describes also contains social commitment mechanisms in the form of a promise to invest, such as, promoters of capital and labour, as well as thermodynamic intensity offered by fossil fuel sources. It is interesting that territorialised, rule-based assemblages produced ‘Quaker capital’. Another social pressure at the time was the price of fodder for horses because of shortages after the battle of Waterloo, and coal offered an alternative ‘horse power’ delivered through steam engines, which were themselves particularly significant nested assemblages within railway development.

Various other rail-way based assemblages were trialled at this time, including the securing the carriages of the upper classes on flat waggons (2014, p21). This is a form of territorialisation, which soon gave way to all peoples traveling in carriages, including Queen Victoria in 1842, in a special coach showing re territorialisation within the new assemblage, as does the rule based first, second and third-class differentiation in carriage designation. Royal trains and first-class carriages offered a place that is free from the crowd – a territorialised space that changed the topology of their aesthetic space. Many early railways were not selected for use, especially where they were not direct or not form a ‘natural system’.

Politics at every level affected, and were affected by the development of rail, and its spread was helped by Thomas Gray’s ‘observations on a General Iron Way’. Faith details how differently rail developed around the world as the social, political, and geographic landscapes differed. In new materialism terms, each rail system has specific beginning where its development as an assemblage depended upon specific socio-political and geographic influences. In some cases, there are attempts to territorialise the railway by building rail lines with a specific gauge. Others deterritorialised by adopting the gauge of other railways within their own borders and with bordering countries. Those decisions happened as the result of decision makers at many levels, and not by ‘the individual’ or ‘society generally’. The adaptation of transport to rail systems offers an historical case study of the production of novelty through the unfolding of a difference in intensities. It is a study of the development of a new system where material and social changes happened far from equilibrium. It is a study of intensive differences that drive dynamical processes.

From the development of steam powered railways, we can say that social change is contiguous with the material changes occurring at the time. Of this, Latour (2008) is critical of how the Modern movement continue to use methodology and analytical tools that assume there is a dichotomy between events of the natural and human world. We need an understanding that processes emerge from an interaction of matter in all its forms and human materials are part of the evolutionary processes that continues to unfold as part of an evolving world. In this rail example, culture and matter are entangled, and can be seen to be so as the development creates a new socio-material space far from pre-steam powered rail transport equilibrium. The grand process of delivering rail systems to the world has an historical account of this seamless integration¹⁴ where the thermal differences create a power source within an existing system of rails, drays, and a motive force. This example shows how cultural and social changes are embedded in the material world and co emerge. The development of rail systems shows how this cocreation of social systems comes about, while most history focusses on the decision making of humans and is far less specific about the environmental determinants of the development of culture and social preferences.

The harnessing of steam power provides an example of the effect that large amounts of high transformity energy (coal) had on patterns in social assemblage. The application of this energy to transport exponentially increased the rate of change to the social system of the time. The way steam powered railways developed and how innovation developed is usefulness in different countries is an example of how local and specific inputs influence the novel properties of an assemblages

What the development of rail shows is the intensity of human feedback systems exercising perception-action cycles through the perception of emergent effects and the attempt to intensify them. The incremental development by engineers and mechanics supports assemblage thinking through the historical and incremental development of skill and information, and concurrently undermines ideas that progress is marked by sudden paradigm shifts characterised by events unrelated to time and space. The rail development also reflects the topological aspect of transport; of edges and nodes. The rails under carriages when considered as physical edges upon which iron wheels ran are significant in overcoming the friction of distance and resultant shortening of time between nodes.

¹⁴ I am referencing Latour here. He calls the evolutionary space an ‘impure nature, one in which culture and matter are seamlessly welded’. B Latour, *We have never been modern*, Harvard University Press, Cambridge, MA 1993.

Early travellers on rail remarked on the experience they had as an essentially conceptual treatment of space that is gained. One description of topology is that it treats problems as geometric, without focusing on fractionated geometry, or a segmented world, but instead describes the underlying shape, or topology of a problem, or terrain in this instance. Rail transport originally flattened the terrain for a very physical reason, and that is because early steam engines were unable to manage gradient and so had to have a flatbed to be able to run at all. Consequently, the initial sensation of rail transport was generally regarded as being very smooth, where travel at 40kph on a train was reportedly more pleasant than traveling any speed in an un-sprung cart or horse drawn coaches (Faith, 2014, p. 16). The sensation of rail travel therefore greatly contrasted the rough and rocky - to the point of carts and wagons overturning- travel on pathways and roads that were rutted and rough.

The aesthetics of the first impact of trains as transportation describe its topological connection. Travelling on a flat plane gave a new aesthetic as the traveller was at one time above the terrain and at other times travelling through deep cuttings where only rock could be seen. Fanny Kemble describes the experience thus: (2014, p.38):

“You can’t imagine how strange it seems to be journeying on thus, without any visible cause of progress other than the magical machine, You cannot conceive what the sensation of cutting the air was: the motion is as smooth as possible, too....this sensation of flying was quite delightful and strange beyond description; yet strange as it was, I had a perfect sense of security, and not the slightest fear”.

Should this have been written today, the magical machine could easily have been the Madrid to Barcelona fast train with the topological time and space elasticity it afforded at 300kph. Ten times the speed to gain the same aesthetic ‘buzz’

7.5 Kaikoura Coast and transport systems.

Is the environment determining how transport happens, and is this in turn structuring social interaction – a process that doesn’t rely entirely on human systems? Transport systems still are still developed in places where human systems ‘fight’ the natural environment. Within New Zealand the Kaikoura coast line is an example of this. A similar problem exists in the Manawatu gorge and is being looked at in quite a different way. In the case of the gorge, its transport potential is being abandoned, as the road space is constantly over run with rock fall. It is an example where the material properties of the gorge are not conducive to clear road ways. The Kaikoura coast suffers from similar problems of rock fall, with the additional complication of earthquake damage and sea

swells. In this case the road is being cleared and reopened after being closed by an earthquake in November 2016.

For goods moving into Christchurch traveling by land from Auckland, via Wellington there are many known tectonically active ways that can disrupt transport. Freight originates in Auckland, a city built on nine volcanoes, the most recent of which erupted 550 years ago (Geologically yesterday). The road system to Wellington then passes through the volcanic plateaux where there are active volcanoes venting heat caused by the friction caused by the Pacific Plate sliding under the Australian plate. Plate tectonics and movement are evident in Wellington where uplift is documented by shoreline shape and the emergence from the sea of the land upon which the airport runways stand. Recent earthquakes in the capital city caused by movement of faults on the east coast of the South Island demonstrate the intensity of pressures where plates are colliding in that region.

Currents and winds are intensified in the Strait between the North and South Islands making crossings from Wellington to Picton a perilous journey at times. The foundering after running aground on Barrett's reef in Wellington harbour of the ferry Wahine in 1968, one of at least 18 significant sinking's caused by gales and heavy seas, demonstrates the intensities of wind and tides here.

The 2016 earthquakes in the Kaikoura region moved the South Island 6 metres towards Wellington and raised the seaboard 8 metres in places and fractured the land in a combination vertical, lateral fault movement (Davies et al., 2017). The geological history of activity of this area describes how the plate collision zone raises and folds the seabed causing locally the Kaikoura mountains. The sharp uplift zone shows how recent this activity is, and the multiple landslides on the coast are testament to the capacity for erosion and rockfall experienced during the earthquake.

In summary, the geological capacity to affect the road freight is historical and knowable between Auckland and Wellington. Of note is that a sea leg cannot be currently avoided. Within this transport assemblage scale of impacts are large and can be compared with Odum's description of the nature of pulsing systems covered in Chapter 3. A model where impact is non-scalar – that the capacity to affect and the capacity to be affected are of very different orders. Such events are part of the open ended becoming of material systems and so the capacity to affect is not predictable in a linear sense.

This example is written to emphasise the direct impact material systems have on social processes such as the rapid delivery of every day consumables over large distances. Within a simple supply and demand model, distance is firstly a factor to overcome. The insistence of having a road link

through such an area that is vital for economic health comes into question using my transport ontology. The system lacks topological control over where things are produced, how alternative routes, such as coastal shipping might have an overall benefit to the health of towns, cities, and the country in general. The insistence of road as the primary mode for freight movements between the two main islands of New Zealand also shows the effects of institutions such as the Road Transport Forum as powerful assemblages.

7.6 Social change, scarcity, and waste flows

In this section I briefly cover how transport is integral in the materiality of social change, and of waste flows. The social unrest in Syria provides an example of how it is possible to measure assemblage intensity and the effects on culture and political stability. The Centre for Climate and Security (Werrell & Femia, 2017) have found that by observing changes in climatic conditions from satellites a direct relationship can be established with the changes in intensities as the main reasons for the uprising caused by social, economic, and political factors.

A challenge to methodologies that generate scenarios and model the potential for change is to include only the more significant assemblages within which rates of change result in a large gradient degradation of energy. To be effective this requires the identification of parts of the assemblage that are subject to large differences of energy potential and to identify these in relation to different scales and types of processes. Consistent with neo-materialist ontology some of these entities will be natural processes, and some are there because of the presence of human minds, and many will be a mix of social and physical materials. It must do this with reference to the underlying 'abstract architecture' that lead to the final entity. This concept follows from the work of Odum and his employment of a macro view instrument that I described in Chapter 2, so that what is studied is at a level of general process can reveal the abstract architecture of the situation.

The recent civil unrest and war in Syria provides a case study of how a study of changes in intensity speaks for such a macro model conception. Gleick (2014), who is part of the water programme of the Pacific Institute describes how several factors changed as the conflict intensified and argues that the civil war can be traced to factors related to 'drought, including agricultural failure water shortages, and water mismanagement'. These factors contributed to 'the deterioration of social structures and spurring of violence' and quotes several sources that concur with this conclusion. De Chatel (2014) also identifies a core problem for Syria as the long-term mismanagement of natural resources. She calls the intensities of interest 'triggers' where it is hard to identify the one that 'broke the camel's back' (p521). De Chatel's assessment is that there was not a sudden catastrophic

event, but exacerbation at the deterioration of many parts of the social assemblage. The triggers referred to here are much like a shift within a space of possibilities towards a phase transition point, or a threshold as it is called by DeLanda. In Syria changes that brought about crop failures led to migration to urban areas that resulted in increased unemployment, and economic dislocation and social unrest acted as a multiplier on socio-economic pressures that were already intense enough that they were destabilising the country. Exacerbating the unrest were the considerable problems with the institutional framework responsible for poor water management decisions, poor planning, and policy errors (Gleick, 2014, p. 334).

Failed economic policies as described here are social materials that are unsuitable for the maintenance and management of economic reforms when undergoing transition to a social market economy, and the resultant failure to do anything about the mismanagement. A discontent at rural levels about the methods of agricultural development and water management created pressures on food supplies. While a healthy system can cope with 'normal' drought conditions and recover, the overgrazing in rural Syria resulted in the collapse in the output of farming assemblages, which in turn changed the demographic dynamics. Rapid changes in location, from farms to urban followed as the result of the unsustainable water use and ground water extraction, where it was pumped at a rate that exceeded recharge –again, a change of intensity.

At a social material level, media didn't report the problems originating from the corrupt and rigid water management programme that concentrated only on the supply side during a massive change in irrigation intensity that doubled in twenty years. Diesel pumps in this case play a role as 'rate of change' intensifiers as the pumps they powered depleted the water table. This means that to understand what is going within a system it is necessary to understand and compare the rate of change of the significant effects on the performance of an assemblage.

The Syria 'problem' can be analysed as material interactions that include human interactions within institutions as material entities with political religious and social expressivity. Changes to natural flows of water and deterioration of other environmental conditions feedback to those who support and are supported by institutions. Political institutions did not communicate the type and nature of the problems. Here we see changes in territorialisation and rule-based processes with an outcome that led to widespread unrest. Central to these changes are the influence that transport systems have within the weather systems, as well as water pumping and the relocation of large parts of the rural population to urban centres.

The above examples show how significant the energy budget (examples of this are the energy for transport, fertilizer or to pump water) is as a powerful influencer in assemblages. There are a range of wider implications for New Zealand. To better understand the interplay of energy and foreign trade, Odum, HT & Odum, E (1979) developed a simulation model of New Zealand 1852-2000 that incorporated many of the systems thinking and simulation of abstract processes covered in this thesis. The model included natural energy sources (solar, wind, waves etc.), exports (including meat, wool, and timber and even educated people) and imports of oil, phosphate rock (for fertilizer) and goods and services. Their work exposed the significant vulnerability of the New Zealand economy to increases in the price of phosphate (now thought to be approaching peak production) because of its very high energy transformation ratio where a significant factor being that the current price of phosphate significantly undervalues its ultimate proportionate energy contribution (via greatly increased primary production) to dollar flow. A conclusion of Odum and Odum's 1979 study of New Zealand's energy balance is that they believe that 'ultimately New Zealand will have to change from its export import base' – a very different finding from the dominant views in New Zealand at that time, and at present. This work could be revisited using transport ontological commitments and neo-materialist metaphysics of assemblage to evaluate risk and opportunity with and across New Zealand's borders.

Recalling his view that maximum power flows to organisms and entities that develop ways to collect more power from the energy available to them, it is concerning that New Zealand's current situation is that the energy embodied in exports is greater than the energy embodied in imports. The consequential net loss of power expressed this way does not shown as such through balance of trade figures. Understood in this way of the current freight transport system aids the net loss in energy terms. While the emphasis remains focused upon the transactional efficiency of logistics, the realisation that New Zealand will have to become more conscious of energy flows over borders, and aware of its geographic isolation has yet to come about.

Central to transportation in living systems is that material flows entailing energy flows always create large waste flows and this helps to explain why nuclear plants create waste at a scale too great and long lasting for the waste disposal capacity of the planet. Currently the use of fossil fuel is creating a carbon footprint that is twice the natural carrying capacity of the planet (Hoekstra & Wiedmann, 2014) as large flows of waste, or high entropy energy are exhaled into the biosphere. All living systems require transport to take away waste, whether via air flows, water flows or pumped flows, and once taken away must reside somewhere. For example, the city of Auckland's growing population not only needs housing, but its growth continues to drive increasing demand for water

and waste water services. A new wastewater tunnel from Western Springs to the Mangere treatment plant will be 13 kilometres long and take ten years to complete, including crossing under the Manukau Harbour. As with all living systems the transportation of waste out of the system is essential and Auckland is faced with needing to spend \$4.8 billion over the next ten years to upgrade and increase capacity (Watercare, 2016).

Transport flows in ecological systems show that all activities maximise the potential energy at every layer, meaning that the maximum amount of work is extracted as entropy increases. Evidence of this is found by looking at energy radiating from different ecological systems. Research shows that mature forest re-radiate the least energy as energy entering the system gets degraded at multiple levels (Schneider & Kay, 1994) and this supports Odum's findings that persistent systems are those that degrade energy most effectively. A comparison of a heat pump and a radiant heater is an example, where high transformity energy used to heat a room directly wastes more heat than when some high transformity energy is used to operate a pump that extracts lower quality heat from the environment to heat a space. This succinct example points to the potential for similar analysis of any system of transport or flow, and future applications of my transport ontology.

7.7 Chapter summary

A naturalised transport ontology highlights the way that transport systems within and between assemblages are very influential in determining the properties those material entities and is the case at all scales. The application of transport ontology to processes of transport has a significant capacity to affect the properties of entities and assemblages. This approach to transport analysis complements the current methods of analysis focussed upon the extensive properties of systems once change has occurred. Adding new analytical methods that focus on intensive processes draws out ways that transport and the movement of matter influences material and social interactions

While hydrocarbon fuel currently changes the topological value of distance, the movement of matter is still a constrained physical process where the friction of geographical distance remains central in the relationship between space, power, and social structure. My ontology does not claim to be predictive but offers the inclusion of abstract processes that shape the material world through transport flows to inform and monitor the unfolding of future between the expression of materials and the intensification of resources that transport brings.

Transportation's transformational power changes culture, by redefining norms and practices. It changes the territorialisation and effectiveness of commitment devices and

self-regulation of social processes. This culture change process questions the modernist belief that matters of culture evolve between and within the minds of people and suggests that changes in the material world, is a determinate of cultural beliefs and decision-making processes. LeCain calls this the human denial of the power of matter (p18). What a neo-material ontology allows is a clarity of the social role undertaken by the material processes of transport. It opens the way to see humans as contingent structures of matter within and entangled in all other flows of matter. The point clearly made by LeCain that 'the material world creates us and our diverse cultures every bit as much as we create it' has direct application to transport research as transport is both a process of that material world and a process of social development. The ontological commitments demonstrated to exist in the examples given in this chapter are consistent with Odum's findings that societies are not just the product of humanly thought up and constructed regimes from ideology but are fundamentally shaped for the long term within an ecological context and the availability of good earth and water, and of other resources with available energy to the society. The shaping and continuity are often executed by transport as the mechanism of making change to society within the greater environment. More importantly the examples show natural transport ontology challenges the traditional and dominant current approaches to transport studies and transport systems that posit them as human created and able to be analysed independently from thermodynamics and energy and material flows. Such human exceptionalism is specifically rejected in this ontology.

Chapter 8

Conclusions

Every organised individual forms an entire system of its own, all the parts of which mutually correspond, and concur to produce a certain definite purpose, by reciprocal reaction, or by combining towards the same end. Hence none of these separate parts can change their forms without a corresponding change on the other parts of the same animal, and consequently each of these parts taken separately indicates all the other parts in which it has belonged.

(George Cuvier quoted in Francis, 2007, p. 195)

8.1 Introduction

I set out in this research to generate a correctly posed problem about how transport developed, is developing and operates in development without knowing where these general questions would lead me. It seemed that there has been no significant change in the presuppositions of why goods move since Cooley recorded his theory of transport in 1894. While what it could move during the intervening years goods transport in economic systems has been widely exploited. It has increased exponentially when measured as distance covered, and tonnes carried. The development of mass production, containerisation and globalised market reach have all occurred without there being a major reconsideration of the nature and ontology that we call goods movement. The research found that the ready availability of petroleum since the middle of the 19th Century had led to a change in basic assumptions away from transport as a 'service to society' as theorised by Cooley (Cooley, 1894) to one where space is collapsed, and geographical distance and physical constraints have been replaced by a neoclassical economic and neoliberal social description of transport as derived demand of production functions. Such an impoverished approach places the overall health of society at risk as decisions are made without considering the wider role that transportation plays in maintaining an ongoing healthy social space. My project shows that thermodynamics, and evolutionary biology when understood within a neo-materialist metaphysics provides a different and richer perspective on transportation within evolutionary process.

My interest in the theory of transport began with a barely formed question: Why does transport happen at all? The subsequent research journey began by looking at the big influences on transport processes; that is energy flow and directionality, and questions about how this fits with institutional

(transport) decision making that for a century has treated access to high quality energy source as a given. When looking at the actual processes and functioning of transport I found similar characteristics in many domains where ecological studies provided particularly good access to understanding transport in living systems. That led to research at another scale where molecular biology research tools can show how cellular systems contain transport complexity like that found in modern goods movement companies and has done so for billions of years. This supported the commitment to combine energy flows with evolutionary processes and an account of the development of transport in living systems.

Taking this path led to an exploration of what would constitute ontological commitment for transport processes generally. I particularly valued the opportunity in the early part of this research to enter what Gunter (2014), describes as a space where there is a deferment of disbelief. I needed license to find a way to openly and intuitively explore the concepts of causality, teleology, energy quality and end directedness as phenomena that relate to transport. Through speculative thought and intuition my research process developed by questioning the presuppositions that determined how goods transport topics are chosen for research, what disciplines are called upon and what methodology determines how the research methods are chosen. I also considered and questioned how the management of transport is understood as a political-economic tool and the geopolitical focus on the protection of supply chains and energy security concerns. Transport viewed in this way extends a more conventional assessment as spatial geography or a focus on engineering efficiency

The open investigative approach took phenomena at face value and traced their historical development and identity and ontological claims they make on what there is in the world. I offer a naturalised transport ontology best described as scientific ontology that has the capacity to be observed and measured and that will pass scientific rigour while expanding meaningfulness through its application.

This scientific approach was greatly aided by current research that is creating new information about transport activity at a molecular level using instrumentation that creates access to, and makes observable, cellular mechanical activity. A review of molecular level research also identified communications networks and the spatial awareness that cells have of their environment and surroundings. These recent developments show processes that were not even imagined ten years ago and offer a rich resource for transport theorising. It offers a different approach to the current research paradigm with its underlying assumptions of reality and its makeup, that to date have excluded the possibilities and ways to understand transportation. It is here that technology and new scientific tools exposed new ways to explore our world at a faster rate than changes in the

philosophy of science of how matter moves and interacts. The new ways to observe the world weaken constructionist explanations as proffered by Luhmann (1990) and theories that the world will remain inaccessible with reality being only that which is constructed through observing the observers, or as Wan describes 'how society observes itself and is observed' (Wan, 2011, p. 16). In place of this kind of closed circle argument, the observation processes of self are put aside in deferment to central ontological claims that perception in ecological systems can be directly of a real thing and occurs without the human brain needing to add interpretations about what caused the input for what can be meaningfully observed. My analysis highlights the anthropocentric way that transport has been conceptualised with underlying presuppositions which in operation are idealist and constructionist. While materials are the thing that transport moves, the current presuppositions appear too limited in their explanatory power. This search was framed with a focus on emerging neo-materialists thinking and realist ontology and a commitment to recognising a far greater role of material interaction in the world. The importance of a materialist ontology for human observers is to keep perception as direct as possible, and I suggest that this can be done by asking: what is it that produces activity?

The challenge was to explore the foundations of transport systems and determine how transport is engaged or maybe entangled in actions that affect living systems. This was a much wider research mandate than to the drivers of transport programmes as consequential responses to economic decisions. The findings that there is more to discover about freight transport than that currently within the transport research paradigm should encourage the exploration by different methodological approaches. However, to avoid over generalising, my focus of this project is limited to goods transport phenomena found within thermodynamic, ecological, and socio-economic domains at different scales. This does not preclude and should encourage exploration into the mega and micro-world to test out the meta theories needing an ontology commitment and expose research to a yet to be determined class of known unknown knowledge and unknown-unknown knowledge. However, the 'unknown-ness' is tempered by accepting the selective capacity of thermodynamic flow as part of a theory of abstract machines that operate at many scales, and how communication and transport are examples of perception and action processes in the creation of complexity and structure.

I have found that the information and knowledge about transport being discovered within the micro world, has only a limited research-based history to guide its development and so information I find significant as transport theory is often stumbled upon rather than purposefully sought-after. That is, we are presented from this research with new information about transport process that is yet to be

embedded in our 'umwelt' as common knowledge. What is being discovered is new to the epistemic world and adds new dimensions and greater complexity to the theory of transport in living systems. The application of scientific artefacts offers better ways to understand how living systems exist than earlier explanations that evoke the domains of the gods, a dependency on luck, magic, or invisible hands. Sometimes what is seen for the first time may take many years before it is understood enough to clarify its ontological commitment to what exists in the world.

The ontological commitment discussed in this thesis supports theorising transport as a naturalised process within a powerful and interactive natural environment. Natural transport processes are driven through intensive difference, driven by gradients in chemical and heat environments that act on and are acted upon by materials in contact with each other. Properties of wholes are produced by the interactions of their parts, in process including transport and energy flow. In this environment the innate properties of matter interact to create new properties that act back on the properties of themselves and other assemblages, including social assemblages. My aim has been to extent this type of thinking as transport ontology that aligns themes of thermodynamic flow and entropy path selection and cellular construction to work coherently as a central explanatory commitment to transport processes of production that help explain how life and complexity develop. The decision to explore this question using the metaphysics of neo-materialism both supports and informs this ontological commitment.

8.2 Returning to the research question

This research project began with the realisation that the bulk of the literature on goods transport focusses on creating economic prosperity. The main research problem was to explore the perceived inadequacy of the current theoretical basis for transport. I struggled with the very restrictive definition of transport as existing as a derived demand of other production functions and considered it an impoverished version that masked a deeper understanding. My question became condensed to 'what is transport' and this offered a freedom to search out the more direct way transport operates in other than human engineered systems. My methodology became one that focused less on what is carried, but why it is carried.

I have argued for a transport theory expanded in scope and meaning and so considered transport phenomena via a meta-analysis of what occurs in systems and how the transport process is understood, if not merely assumed. I again refer to Odum's 'macroscope' tool as a methodological way to view human social systems objectively and to map environmental systems architecture. It

allows a viewpoint of the reality of human activity to be seen within the context of the next level up, the N+1 view.

That journey led this research firstly to look at ecological systems and then to look at transportation within cellular systems. My research extended from a macro global to a micro and molecular joining and parting of material entities. The time scale of this research took me back nearly 4 billion years to witness the first deployment of transport systems in the origin of life. Curiously at that singular moment I found through the biological research reported that there are Mainfreight like depots in every cell.

The reason my access point to this enquiry is via transportation phenomena was that it seems to be an under theorized and assumed activity in many fields of research. I had found that discoveries of transport and communications complexity in biological systems are often subordinate to the main aims of a research project, with the levels of sophistication stumbled on providing a 'surprise'. I was then drawn to Nick Lane's conjecture about how cells first formed 3.8 billion years ago, as his theory links transport, thermodynamics, and the evolution of living things at the very beginning of cell development. My research sub-question was driven by an interest in whether there are material links between mechanisms of goods transport and an emerging evolutionary account of how structure and complexity develop with my guiding assumption being that advances in thermodynamics and evolutionary biology challenge the current underlying assumptions about transport. This led to my overall research question: is the development of a new theory of transport needed, and in what way could it be applied to current freight transport research?

I answered this question by firstly considering biological systems from a thermodynamic and evolutionary perspective and this led me to explore inherently physical and material explanations for the behaviour of living systems. The puzzle included an apparent directional scalar and systematic behaviour within living systems, and the missing part was the shape of transport in the big picture. Finding out what this is led part of my research to consider recent discoveries of transport systems found at a molecular biology level and to think about how what I found out pertains to goods movement logistics as generally understood. I then needed to make sense of why the complexity of bio-mechanical and informational systems found in cells show as consistent structures via thermodynamic processes that are found at other scales and levels in ecological and social systems.

I found consistency at every level and up to the scale of international transportation across borders - through gates - and how it affects energy flow is considered with reference to Odum's view that

systems that extract maximum potential energy from their energy flows become the healthiest and most sustainable. To date, goods transport is not seen as part of a cascade of energy flow, as high transformity energy is abundant and priced at a much lower cost than represented by its potential energy. The point is that the most resilient systems extract energy/create entropy in a cascade process that maximise power to systems and that is not considered important for commercial systems.

My method for addressing the question was firstly analogical: comparing freight transport with other processes based on a perceived similarity and claiming there to be an ontological basis to this perceived similarity. This raised several subsidiary questions. Is the analogy appropriate? Does the perceived similarity owe to an ontological similarity? What are the difference between cellular transport and freight transport, and how are they significant for our understanding of the latter?

My research into transport as a natural system found that populations that survive do so because they have developed both internal governance systems, and boundary control systems to moderate their relationships with the outside world. Molecular and ecological populations show how this survival process has created the world as we now live in it through the exercise of controls mechanisms. The more that is found out about how these controls work, and the possibility of natural intelligence in non-human systems, suggests that all living things survive because they have complex communication systems and so are informational in a chemical and material way at many levels. The interaction of the capacity to affect and to be affected within entities and their environment is important in how living systems are defined. How the control of matter-energy flows between entities is characterised by topological governance. The informational mechanisms that define what this means are still being discovered but an emerging characteristic in material systems is that information interacts with physical transport systems of matter to ensure survival. What I take from this is that survival of any population of entities, and in this I include human social systems, and the matrix of transport systems that enable the way society is structured, is contingent on highly specialised perception-action information-material loops. The ability to identify and engage with matter-energy flows is central to successful selection strategies where, over time, search devices explore the space around them. The long game here is not dominance through competition, even though competition for resources is part of the evolutionary process, but survival through optimum resource access, management, and use.

Search devices that operate in dissipative fields find elevated spaces of optimal performance and through selection pressures the emergent entities maximise dissipative powers and stay there. Variations within that population that are less stable fail. Cells are an example of this peak

performance stability, where variations have failed to offer anything more beneficial to the organism.

The solutions that support the survival of entities in these spaces is contingent on stability of the environment. If the environment changes, the solution may no longer an optimal one where variations through replication and sorting devices search out and explore the possibility spaces for new forms.

The space of exploration is not unstructured or chaotic but has the property of hosting emergent properties. For such a space to have the capacity to generate emergent properties there must be a continuous and dissipative energy flow, zones of stability and regions of bifurcation. The power that transport exerts in a way that alters the relations between and within assemblages is under theorised. This offers an opportunity to expand the knowledge of the ontological commitments that support new theory by focussing on transport within studies of emergence and evolution. This would support the finding that there needs to be better understanding of how the governance of transport is central to the health of any system.

8.3 A broader definition of transport

Transport is part of the production of emergent properties and new non-reducible, but analysable entities. I have argued that transport systems operate in highly complex but not yet fully understood workspaces at the convergence of energy flow and matter in a way that is consistent with Soddy's (1912) scope of movements of commerce and industry, social welfare, war and political stability. James (1910), in his almost flippant quote that I start this chapter with refers to trade as a method of plunder and indirectly implicates transport as a facilitating tool for the accumulation and wealth through trade, notwithstanding its potential as a tool of plunder. James view shows how wide ranging the changes to social structure can be. I have argued that there is a strong connection between the laws of matter and energy that Soddy believes underlie the whole record of human experience. It is timely now to offer a more complete definition of transport that addresses the broader function and effect it has on how we live.

To give a broader definition I first needed to consider how the definition is shaped by ontology. What an explicit ontology does for the definition of transport is to include transportation processes within the systems served, and not treat transport as an aftermarket accessory. By doing that transport can be considered as active parts in Heidegger's philosophical notion of *Dasein*, or being-in-the world, which is the opposite of the Cartesian notion of being a product of some other 'thing

that thinks' (Brittanica, 2016). It engages, allows, and expands transportation's role in continuous communication between self and the surrounding environment or at a different scale, world.

Cooley's theory of transport recognises the close connection between transportation and physical geography and I have further expanded the scope to explore the processes that create structure and define the transport facilitated relationship of living things and their environment. The influence of physical geography featured in Cooley's thinking about the social implications of his theory. He said "one cannot hope to understand transportation without the geographical facts that condition it" (Cooley, 1894, p. 74). To this I would add that a 'fuller understanding' requires thermodynamic and energetic inclusion to reflect transport's role as an inherently physical process of concentration, differentiation, and diffusion. As found in Cooley's definition I include in my broader definition the governance role transport plays in maintaining an organised society. Current research into molecular biology and related chemical processes indicates that these processes constitute parts of a larger and more sophisticated physical intelligence network with an epistemic self-modifying ability to maximise its environmental presence.

I didn't expect to find the level that I have of common structure and overall similitude in transport systems at so many different scales or material content. Nor did I think there would be so little research focus given to why and how extensive transport presence within processes inform an evolutionary theory of life arising whenever possible. I was also surprised that the general question of what mechanisms and lawful informational processes are needed to support active and often orthogonal transportation activity has not been addressed to any depth. It maybe that a research focus on gene frequency and coded information may have occupied scientific research programmes to the detriment of research that considers cells as places of space and active physical and material systems that have DNA information embedded as a compliment of a more complete system. It seems that when researchers discover something interesting about how transportation works, or is controlled, the focus of the research is confined to what benefits there may be in terms of human health of the direct body or cell in question. My research identifies a meta-analysis opportunity for exploring the impact and consequences of transport on the health of 'social systems', at every level of scale.

Research suggests that cellular governance extends through the whole of an organism and does this while also constantly monitoring the external environment. A major consideration is that if we accept that cell transport is linked with barrier permeability and governance of process, then an understanding of systems at a cellular level can influence our thinking at a social level. It challenges the idea that there should be no barrier or no regulation of flows between entities, and that is the

major ontological change. Living systems are governed in the movement of materials between cells or entities as part of their persistence and claim on longevity.

This research finds that while living systems follow lawful processes, particularly energy flow, the same can be said of social systems. When we look at transport and communication links identified at a cellular system they are silent, and we are objectively removed by the differing scale in our observation of them. However, when we consider social systems within which we are embedded the information flows are exceptionally noisy and overwhelming in scale and are expanding exponentially as social media increases networking. At the same time there is pressure to reduce topological governance of processes that I have argued are vital to the persistence of living systems and shown to be highly controlled and organised in systems at other scales where I have been looking at their transport.

8.4 Contribution of ontology

I have found that transport is active in the production of emergence and has important evolutionary significance. Part of this is the way that transport processes at different scales have similar abstract architecture, or diagrams, and that neo-materialist, realist metaphysics offers an epistemological fit. It is a metaphysics that applies equally to transport and materials in any system and I have identified Assemblage Theory as offering a way to express the explanatory insight gained of transport processes.

A major contribution ontology can make in general is to encourage interdisciplinary research about how the deepest of theories can be associated with scientific practices leading to more complete explanations that lead us to better understand how the world works. The response to immanent properties that express and combine into entities with non-reducible properties is an explanation of how materials interact and not a search for a unified theory. It is a commitment to the existence of abstract architectures and the significance of gradients enabling flow where new entities emerge in the state space of the Earth. It is an emergence of novelty as the potential found in all reality becomes progressively segmented and undergoes active assembling in energised matter.

The naturalised transport ontology so developed encourages this to happen by using transport systems research to identify physical and order building properties in the search for better explanation of why life has developed the way it does. Part of why this could be successful is the very intimate association transportation has with both energy and matter and the scope this offers for evolutionary processes. When the semiotic structure forming processes that support the expansion and maintenance of living systems are now being found a rich picture of why life is the way it is

begins to emerge. The exact workings of the process are still opaque but that should not detract from pursuing an autocatakinetic and physical information process as an extension of living process and a real thing in the world. Exactly what that means has yet to be fully explored and as covered in Chapter Five, Marijuan has called this line of enquiry an informational approach to living existence (Marijuan, 2009). In his ongoing research he expects his team to find that informational energy and informational structures, of which autocatakinetic systems seem to me to be of the type of structures he develops, will 'transcend adjacency'. This he says will come about through a change of perspective in the development of information science (Del Moral, Navarro, & Marijuan, 2014b) and how it choreographs life (Marijuan, Navarro, & Del Moral, 2015).

The importance of elevating a richer base for theories of transport is a practical invitation to incorporate the new knowledge about biological organisation and an opportunity to reinterpret processes that intertwine concepts of self-production and communication that accepts natural systems informational transfer into a thermodynamic environment and so create several areas for future research. An aesthetic aspect is the understanding and 'materialisation' of the creative flows of materials where singularities act as attractors leading to the emergence of persistent entities.

The ontology allows alternative views of the importance of transport to the regulation of systems by energy feedback mechanisms that create a positive tension between the lawful directionality of energy flow. Transport becomes central to all existence through flows into, through and out of open systems through cycles of growth, climax, decline and regeneration. Goods transport then becomes situated in explanations of this phenomena via a broader and lawful understanding of thermodynamically enabled directional processes. I have shown that the recent access science has to the macro, micro worlds creates artefacts and engines in social structures that have no historical precedent, and access to ways of living for which there is no historical precedent. The description of what Captain Cook discovered is described poetically as 'simply by sailing in a new direction you could enlarge the world' (Curnow, 2013) and this turn of events can also apply to discoveries of new worlds at other scales, making the challenge for neo-materialist science an equally exhilarating voyage. As Curnow considers Cook taking stock of the more probable conjectures about the unknown to be traversed, our current need for making sense of what is discovered at other scales of existence also necessitates a constant review of the scientific metaphysics of what there is in the world. A realist transport ontology provides a starting point of this journey. It integrates transport within the contingency of permanence and identity of living entities in their relationship to the environment. It provides a material explanation of how transport systems follow thermodynamic and autocatakinetic processes that guide and form relationships of exteriority between assemblages.

8.5 Future applications

This research provides new insights via ontology that allows methodology that searches out flows with the capacity to affect and be affected within the sub assemblages of an emergent entity. The way to explore this further is to have as a starting point the view that emergent properties of, say, a goods delivery system are different to the production processes that formed it. Computer simulation of the sub assemblage abstract mechanisms can explore the production processes, and this will increase the understanding of how transport influences the production of novel entities.

The choice of a naturalised world explanation as the underlying epistemological basis for the study of transport may at first seem different, the ontological commitments could be extended into other fields. Ontology of transport offers a way to inform social development through the common transport or movement where concentrations and separations of people or power occur in increasingly complex living systems. My determination of a naturalised transport ontology could be applied to further refining a different and more materialist view of what 'transport' does. It would contrast with the current bounded suppositions operationalised through graphical methodologies in transport studies and so naturalised and neo materialist transport ontology offers to provide a significant advance to social systems' knowledge. This project identifies some key areas for future researchers to explore including further clarification of how topological governance processes maintain stability of entities like a 'cell' and to contingent assemblages. Further development of this relationship would apply to any entity with relations of externality to any other entity and within any entity with a border that manages interaction with its immediate environment. Further possible implications and questions about transport governance and resource sustainability could open out and further inform neo materialist thinking in this area. Another avenue is an exploration of ways to better understand how transport and assemblage thinking could inform transport policy. For transport we need to identify the general type of possibility space and the changes in assemblages that transport will affect. These are interesting areas for future research to build on or test this transport ontology and methodology. I have achieved the original objectives, through the analysis of arguments of providing a context that explains the relationship of thermodynamics, ecological, and social complexity to transport by identifying ontological commitments that are within the gamut of neo-materialist thinking. I developed an ontology that I then demonstrated could be applied to provide a different view of the word from that traditionally associated with the idealist approach to the concept of transport.

8.6 Final Summary

Transport is an analysable production function of whole entities that connects the capacity to affect with the capacity to be affected found in all material flow processes. That is:

Transport produces situations where materials get close enough
for their properties and capacities to interact.

I have found that freight transport has a strong analogy to action-perception cycles found in the natural world and so validates and strengthens the connection between transport and communication in transport theory. Transport is an active part of the development of structure and complexity. The mid-century interest in studying ecological systems and Odum's findings that healthy and sustainable systems are those that extract all work possible at every gradient in the system, result in creating the greatest entropy flow. Meaningfully incorporating intensive measures into transport theories usual focus on extensive measurement basis changes the focus on how to model and simulate the effects transport changes have on social settings.

By following a neo-materialist philosophical line, I have explained how transport mechanisms and machinery are synthesised in natural and social worlds. The processes manifested are considered real and irreducible and continue while the assemblages of material flows remain stable in themselves and have a stable thermodynamic gradient. I have identified the significance and relationship between transportation gateway mechanisms that control and protect the viability of the cell, and the way that natural transport systems exhibit very clear border control on what enters and leave, and how the overall potential of the system is maximised. Non-human epistemic decisions are made to transport material across borders within the highly controlled topologically governed natural systems.

The stability of processes changes as transport processes alter either the extensive, intensive properties or a combination of both within and between assemblages. Assemblages have innate transport and communication interactions, and their beginnings are historically traceable and explainable in all processes and verifiable through an increasingly more detailed understanding of the process of assemblage of the very first cellular structures.

When transport is considered as a central part of assembling processes it offers a grounding for an explanatory framework to ground arguments for governance and control over materials movement within and between social entities. Transportation within assemblage mechanisms and understood within a neo-materialist philosophy provides a lawfully informed basis for increasing an

understanding the production of novelty within information systems science, thermodynamics, and evolutionary studies. Defined in this way, a naturalised transport ontology generally supports enquiry in to the physical processes leading to populations within which natural selection can occur. Swenson's generalised autocatakinetic schema Figure 16 is suggestive of what may yet to be found, and molecular biochemistry tools are identifying possible mechanisms. The general nature of these interactions are well summarised by DeLanda as where 'events acting as causes actually produce their effects' (DeLanda, 2002, p. 149).

The described transport ontology accepts relationships at many scales entailed in 'perception-action' cycles and manifest as transport and communication. Transport is therefore a central and meaningful part of the reason for the persistence of all living things. Topological governance of transport systems is equally important as the management of network logistics systems where they work together for the viability of the whole entity. Social and political discourse about the nature and role of transportation would benefit from a broader consideration of how entities manage energy flows within regions and across borders. I find that a wider definition of freight transport would benefit policy discussions about freight movement, transport networks and border control. The research project of this thesis set out to identify the need for a new theoretical basis of transport and provides a naturalised transport ontology towards that end.

References

- Ahman, M. (2004). *A closer look at road freight transport and economic growth in Sweden. Are there any opportunities for decoupling?* Retrieved from Bromma:
- Alexander, C. (1977). *A pattern language*. New York: Oxford University Press.
- Alexander, C. (1980). *The luminous ground: An essay on the art of building and the nature of the universe* *The Luminous Ground*: . California: Centre for Environmental Structure.
- Allen, J. (1997). *Cities and regions as self organising systems. Models of complexity* (Vol. 1). Amsterdam: Gordon and Breach science publishers.
- Allen, J. (2011). Powerful assemblages? *Area*, 43(2), 4.
- ANZ. (2016). *ANZ Truckometer*. Retrieved from <http://www.anz.co.nz/about-us/economic-markets-research/truckometer/>
- ARA. (2006). *Auckland regional freight strategy*. Auckland: Auckland Regional Council.
- Atkinson, N. (2007). *Trainland: How railways made New Zealand*. Auckland: Random House.
- Ayres, R., & Warr, B. (2004). *Accounting for growth: The role of physical work*. Retrieved from Fontainebleau:
- Baas, P. H. (2007). *Preparing for double the freight: Optimising New Zealand's freight system*. Retrieved from
- Baird, J. (2012). *Quarantine Inspected: The work of front-line inspectors in New Zealand's biosecurity system*. Wellington: Primedia.
- Baker, C. (2009). *The political constraints of industrial policy in New Zealand*. Essay. Victoria University of Wellington. Wellington.
- Baker, T., & McGuirk, P. (2017). Assemblage thinking as methodology: commitments and practices for critical policy research. *Territory, Politics, Governance*, 5(4), 425-442. doi:10.1080/21622671.2016.1231631
- Ballingall, J., Steel, D., & Briggs, P. (2003). *Decoupling economic activity and transport growth: The state of play in New Zealand*. Paper presented at the 26th Australasian Transport Research Forum, 1-3 October 2003, Wellington.
- Beinhocker, E. D. (2013). Reflexivity, complexity, and the nature of social science. *Journal of economic methodology*, 20(4), 13.
- Bennet, J. (2010). *Vibrant Matter: A political ecology of things*. Durham, NC: Duke University Press.
- Bertalanffy, L. (1969). *General System Theory. Foundations, development, application* (Revised ed.). New York: George Braziller.

- Bird, R. B., Stewart, E. W., & Lightfoot, E. N. (2002). *Transport Phenomena* (2nd Edition ed.): John Wiley & Sons, Inc.
- Bolland, J., Weir, D. Vincent, M. (2005). *Development of a New Zealand National Freight Matrix* (283). Retrieved from
- Bossel, H. (1998). *Earth at a crossroads: Paths to a sustainable future*. Cambridge: Cambridge University Press.
- Britannica. (2016). philosophical anthropology *Encyclopaedia Britannica*.
- Brown, L. R. (2008). *Plan B 3.0*. New York: Earth Policy Institute.
- Brown, M. T. (2004). A picture is worth a thousand words: energy systems language and simulation. *Ecological Modelling*, 2004(178), 83-100.
- Brown, M. T., Cohen, Matthew J, & Sharlynn, S. (2016). Prediction national sustainability: The convergence of energetic, economic and environmental realities. *Ecological Modelling*, 2009(220), 3424-3438.
- Bunge, M. (1979). *Causality and modern science* (Third ed.). New York: Dover Publications Inc.
- Burton, I. (1963). The quantitative revolution and theoretical geography. *Canadian Geographer*, 7(4), 151-162.
- Callaway, E. (2013). Cell transport carries Nobel. *Nature*, 502, 12.
- Campbell, C. (n.d). *The financial consequences of peak oil*. Paper presented at the Edinburgh conference, Edinburgh.
- Carello, C., & Turvey, M. T. (nd). *The ecological approach to perception*. Retrieved from
- Cassidy, J. (2005, 11 April 2005). Always with us? Jeffrey Sach's plan to eradicate world poverty. *The New Yorker*, 81.
- Cavana, R., Harrison, G., Heffernan, F., & Kissling, C. (1998). Freight Transport. In M. Pickford & A. Bolland (Eds.), *The structure and dynamics of New Zealand industries*. Palmerston North: The Dunmore Press Limited.
- Chaisson, E. (2005). Non-equilibrium thermodynamics in an energy-rich universe. In A. Kleidon & R. Lorenz (Eds.), *Non-equilibrium thermodynamics and the production of entropy*. Berlin: Springer.
- Chalmers, A. F. (2010). *What is this thing called science?: An assessment of the nature and status of science and its methods* (3rd ed.). St Lucia: University of Queensland Press.
- Checkland, P. (1981). *Systems thinking, systems practice*. Chichester: John Wiley & Sons.
- Cooley, C. (1894). The theory of transportation. *American economic association*, 9(3), 13-148.
- Cox, C. A. (2012). *The circadian clock and the cell cycle*. (PhD), University College London, London.

- Crotty, M. (1998). *The foundations of social research: Meaning and perspective in the research process*. Crows Nest NSW: Allan & Unwin.
- Curnow, A. (2013). *Early days yet*. Auckland: Auckland University Press.
- Daly, H. (2005). Economics in a full world. *Scientific American*, 293(3), 100-107.
- Daly, H. (2007). *Ecological development and sustainable development: Selected essays of Herman Daly*. Cheltenham: Edward Elgar.
- Daly, H. (2008). *A steady-state economy*. Retrieved from MD:
- Darwin, C. (1937). *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life*. New York: Appleton Century.
- Davies, J., Sadashiva, V., Aghababaei, M., Barnhill, D., Costello, S., & Fanslow, B. (2017). Transport infrastructure performance and management in the South Island of New Zealand, during the first 100 days following the 2016 Kaikoura earthquake. *Bulletin of the New Zealand Society for Earthquake Engineering*, 50(2).
- De Châtel, F. (2014). The Role of Drought and Climate Change in the Syrian Uprising: Untangling the Triggers of the Revolution. *Middle Eastern Studies*, 50(4), 521-535.
doi:10.1080/00263206.2013.850076
- Del Moral, R., Navarro, J., & Marijuan, P. (2014a). New times and new challenges for informational science: From cellular systems to human societies. *Information*, 2014(5), 101-119.
- Del Moral, R., Navarro, J., & Marijuan, P. (2014b). On being informational: Intertwining the communication and self-production flows. *Kybernetes*, 43(6), 846-864.
- DeLanda, M. (1997). *A thousand years of nonlinear history*. New York: Zone Books.
- DeLanda, M. (2002). *Intensive science and virtual philosophy*. London: Continuum.
- DeLanda, M. (2005). Space: Extensive and Intensive, Actual and Virtual *Deleuze and Space* (pp. 80-88): Edinburgh University Press.
- DeLanda, M. (2011). *Philosophy and simulation. The emergence of synthetic reason*. London: Continuum International Publishing Group.
- DeLanda, M. (2016). *Assemblage Theory*. Edinburgh: Edinburgh University Press.
- Deleuze, G. (1994). *Difference and repetition*. New York: Columbia University Press.
- Dennis, S. (2007). *A decade of growth in domestic freight*. Retrieved from
- Denzin, N., & Lincoln, Y. (2000). *Introduction: The discipline and practice of qualitative research*. Thousand Oaks, CA: Sage.
- Dewar, R. (2005). Maximum entropy production and non-equilibrium statistical mechanics. In A. Kleidon & R. Lorenz (Eds.), *Non-equilibrium thermodynamics and the production of entropy*. Berlin: Springer.

- Diggle, S., West, S., Gardner, A., & Griffin, A. (2007). Evolutionary theory of bacterial quorum sensing: when is a signal not a signal. *Philosophical Transactions of the Royal Society B-Biological Sciences*, 362, 1241-1249.
- Dryzek, J. S. (1987). *Rational Ecology: Environmental and political economy*. Oxford: Basil Blackwell.
- Dryzek, J. S. (1997). *The politics of the earth: environmental discourses*. Oxford: Oxford University Press.
- Dryzek, J. S., & Schlosberg, D. (2005). *Debating the earth: The environmental politics reader* (Second edition, first published in 1998 ed.). Oxford: Oxford University Press.
- Easton, B. (1997). *The commercialisation of New Zealand*. Auckland: Auckland University Press.
- Easton, B. (2001). *The nationbuilders*. Auckland: Auckland University Press.
- Easton, B. (2007). *Globalisation and the wealth of nations*. Auckland: Auckland University Press.
- Easton, B. (2008). *Politics, policy and modernisation*. Retrieved from www.eastonbh.ac.nz/?p=903
- Easton, B. (2009). *New developments in trade and trade theory*. Retrieved from www.eastonbh.ac.nz/?p=1043
- EEA. (2017). *Final energy consumption by mode of transport*. Retrieved from <https://www.eea.europa.eu/data-and-maps/indicators/transport-final-energy-consumption-by-mode/assessment-8>
- Emmett, S. (2005). *Logistics freight transport; domestic and international. For managers and students*. Cambridge: Cambridge Academic.
- England, J. (2013). Statistical physics of self-replication. *The journal of chemical physics*, 139(121923).
- Faith, N. (2014). *The world the railways made*. London: Head of Zeus Ltd.
- Feige, I. (2007). Freight Transport and Economic Growth — Two Inseparable Twins? *Transport, Trade and Economic Growth — Coupled or Decoupled? An Inquiry into Relationships between Transport, Trade and Economic Growth and into User Preferences concerning Growth-oriented Transport Policy* (pp. 5-8). Berlin, Heidelberg: Springer Berlin Heidelberg.
- Foley, G., & Nassim, C. (1976). *The Energy Question*. Harmondsworth: Penguin Books Ltd.
- Francis, M. (2007). *Herbert Spencer and the invention of modern life*. Stocksfield: Acumen Publishing Limited.
- Fulbrook, E. (2009). *Ontology and Economics: Tony Lawson and his critics*. London: Routledge.
- Galbraith, J. K. (1958). *The affluent society* (New Edition 1998 ed.). London: Penguin Books.
- Garrison, W. L., & Marble, D. F. (1964). Factor-analytic study of the connectivity of a transportation network. *Papers of the Regional Science Association*, 12(1).

- Geels, F., & Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy*, 36(36), 18.
- Gibson, J. (1979). *The ecological approach to visual perception*. Boston: Houghton-Mifflin.
- Glaeser, E. L., & Kohlhase, J. E. (2003). Cities, Regions and the decline of transport costs.
- Gleick, P. H. (2014). Water, Drought, Climate Change, and Conflict in Syria. *Weather, Climate, and Society*, 6(3), 331-340. doi:10.1175/wcas-d-13-00059.1
- Gorringer, P. (2001). *Economics for policy: Expanding the boundaries: Essays by Peter Gorringer* (V. U. o. Wellington Ed.). Wellington: Institute of political studies.
- Government, N. (2002). *Port Companies and market power - A qualitative analysis*. Retrieved from Wellington:
- Government, N. (2009a). *Amending the government policy statement on land transport funding 2009/10-2018/19*. Retrieved from
- Government, N. (2009b). *Infrastructure: Facts and Issues. Towards the first National Infrastructure Plan*. Retrieved from Wellington:
- Government, N. (2013). *Roads of National Significance*. Wellington: New Zealand Government
Retrieved from <http://www.transport.govt.nz/ourwork/land/roadsofnationalsignificance/>.
- Government, N. (2014a). *Connecting New Zealand: a summary of the government's policy direction for transport*. Wellington: Ministry of Transport Retrieved from
<http://www.transport.govt.nz/assets/Import/Documents/Connecting20NZ-online-version-9-September.pdf>.
- Government, N. (2014b). *Government Policy Statement on land transport: 2015/16-2024/25*. Wellington: New Zealand Government.
- Government, N. (2015). *Draft transport research strategy: 2016-2020*. Wellington Retrieved from
<http://www.transport.govt.nz/assets/Uploads/Research/Documents/Draft-Transport-Sector-Research-Strategy-v2.13.11.2015.pdf>.
- Gregory, D., Johnston, M., Pratt, G., Watts, M. J., & Whatmore, S. (2009). *The dictionary of human geography* (5th ed.). Chichester: Blackwell Publishing Ltd.
- Gribbin, J. (2002). *Science: A History*. London: Penguin.
- Gunter, M. (2014). *Levolution. Cosmic order by means of thermodynamic natural selection*. Bloomington: Archway Publishing.
- Hacker, J., & Pierson, P. (2016). Making America great again. *Foreign Affairs*(May/June 2016).
- Hall, A. S. (2005). *The great scientific coverup of the most important issue in western civilisation: A personal odyssey inot the realm of science*. Paper presented at the Adaptive Peaks Seminar.
www.esf.edu/efb/hall/talks/Coverup5a.ppt

- Hall, A. S., & Klitgaard, K. (2006). The need for a new, biophysical-based paradigm in economics for the second half of the age of oil. *International journal of transdisciplinary research*, 1(1), 4-22.
- Handbook of transport and development*. (2015). (R. Hickman, M. Givoni, D. Bonilla, & D. Bannister Eds.). Cheltenham: Edward Elgar Publishing Ltd.
- Handbook of transportation science*. (2003). Boston: Kluwer Academic Publishers.
- Haramoto, Y. (2010). Cytoskeleton: Motor Proteins. In C. T. U. o. Tokyo (Ed.), *Life Science*. Tokyo.
- Harris, M. (2001). *Cultural Materialism The struggle for a science of culture*. Walnut Creek: Alta Mira Press.
- Hartely, S. (2016). F&P set to close NZ factory. *Otago Daily Times*.
- Harvey, D. (2005). *A brief history of neoliberalism*. Oxford: Oxford University Press.
- Hesse, M., & Rodrigue, J.-P. (2004). The transport geography of logistics and freight distribution. *Journal of transport geography*, 12(3), 171-184.
doi:<http://dx.doi.org/10.1016/j.jtrangeo.2003.12.004>
- Hesse, M., & Rodrigue, J. (2004). The transport geography of logistics and freight distribution. *Journal of transport geography*.
- Hesse, M., & Rodrigue, J. (2006). Global production networks and the role of logistics and transportation. *Growth and Change*, 37(4), 11.
- Hibbs, J. (2000). An introduction to transport studies. London: Kogan Page Ltd.
- Hickman, R., & Banister, D. (2015). *Handbook on Transport and Development*: Edward Elgar Publishing.
- Hirsch, C., & DesRoches, C. T. (2009). Cambridge social ontology: an interview with Tony Lawson. *Erasmus Journal for Philosophy and Economics*, 2(1), 100-122.
- Hodder, I. (2012). *Entangled: An archaeology of the relationships between humans and things*. Chichester: Wiley-Blackwell.
- Hoekstra, A., & Wiedmann, T. (2014). Humanity's unsustainable environmental footprint. *Science*, 344(6188), 1114-1117.
- Hoelzer, G. A., Smith, E., & Pepper, J. W. (2006). On the logical relationship between natural selection and self-organization. *Journal of Evolutionary Biology*, 19(6), 1785-1794.
doi:10.1111/j.1420-9101.2006.01177.x
- Holdaway, R. J., Sparrow, A. D., & Coomes, D. A. (2010). Trends in entropy production during ecosystem development in the Amazon Basin. *Philosophical Transactions of the Royal Society B-Biological Sciences*, 365(2010), 1437-1447.

- Hubbert, M. K. (1982) *Sustainable development - challenges and opportunities/Interviewer: D. Nissen*. Uppsala University, Uppsala.
- IRU-ETF Statement on the economic crisis. (2009). [Press release]
- Jackson, C. (Producer). (2015, 28 May 2016). 1.1 Supply, demand, and equilibrium online.
- James, W. (1910). The moral equivalent of war. *Popular science monthly*(77), 400-410.
- Jekely, G. (2009). Evolution of phototaxis. *Philosophical Transactions of the Royal Society B-Biological Sciences*, 2009(364), 2795-2080.
- Jeram, J. (2016). *The health of the state*. Retrieved from Wellington:
- Jesson, B. (1999). *Only their purpose is mad*. Palmerston North: Dunmore Press Limited.
- JFCom. (2010). *The JOE 2010 Joint Operating Environment*. Retrieved from Suffolk VA:
- Joyce, S. (2010). Freight report supports industry-led approach. Retrieved from www.national.org.nz/Article.aspx?articleId=34254
- Kelsey, J. (2002). *At the Crossroads*. Wellington: Bridget Williams Books Limited.
- Klare, M. (2008). *Rising powers, shrinking planet: The new geopolitics of energy*. New York: Henry Holt and Company.
- Kolbert, E. (2008, 7 July 2008). The island in the wind. *The New Yorker*.
- Kveiborg, O., & Mogens, F. (2006). Decomposing the decoupling of Danish road freight traffic growth and economic growth. *Transport Policy*.
- Lakoff, G., & Johnson, M. (1980). The metaphorical structure of the human conceptual system'. *Cognitive science: A multidisciplinary journal*, 4(2), 195-208.
- Lambert, D. (2004). *Supply chain management: processes, partnerships, performance*. Sarasota, FL: Supply Chain Management Institute.
- Lane, N. (2015a). The unseen world: reflections on Leeuwenhoek (1677) 'Concerning little animals'. *Philosophical Transactions of the Royal Society B-Biological Sciences*, 370(2014344).
- Lane, N. (2015b). *The vital question: why is life the way it is?* London: Profile books.
- Lane, N., Allen, J., & Martin, W. (2010). How did LUCA make a living? Chemiosmosis in the origin of life. *BioEssays*(32), 271-280. doi:10.1002/bies.20090031
- Latour, B. (2008). Its development, stupid! or: How to modernise modernisation. In J. Proctor (Ed.), *Post-environmentalism*. Cambridge Ma: MIT Press.
- Lawson, T. (1994). A realist theory for economics. In R. E. Backhouse (Ed.), *New direction in economics methodology*. London: Routledge.
- Lawson, T. (2003). Ontology and feminist theorising. *Feminist Economics*, 9(1), 32.
- Lawson, T. (2004). *A conception of ontology*. Retrieved from Cambridge:

- Lawson, T. (2012). Ontology and the study of social reality: emergence, organisation, community, power, social relations, corporations, artifacts and money. *Cambridge Journal of Economics*, 2012(36), 345-385. doi:10.1093/cer/ber050
- Lazarus, R., J. (2009). Super wicked problems and climate change: Restraining the present to liberate the future. *Cornell Law Review*, 94, 178.
- Leach, N. (2009). The limits of urban simulation: An interview with Manuel Delanda. In H. Castle (Ed.), *Digital Cities AD: Architecture and design*. London: Wiley.
- Lebel, L., Anderies, J., Cambell, B., Folke, C., & Hatfield-Dodds (Cartographer). (2006). Governance and the capacity to manage resilience in regional social-ecological systems
- Lebowitz, J. (1993). Boltzmann's entropy and time's arrow. *Physics Today*(September 1993).
- LeCain, T. J. (2013). An impure nature: Memory and the Neo-Materialist Flip at America's Biggest Toxic Superfund Site. *Global Environment*, 6(11), 16-41. doi:10.3197/ge.2013.061102
- LeCain, T. J. (2015). Against the anthropocene. A Neo-Materialist Perspective. *International journal of History, Culture and Modernity*, 3(1), 1-28. doi:<http://doi.org/10.18352/hcm.474>
- Lehtonen, M. (2006). *Decoupling freight transportation from GDP - conditions for a regime shift*. Paper presented at the 2006 Berlin Conference on the human dimensions of global environmental change, Berlin.
- Leon, D. (2009). *About Face*. London: William Heinemann.
- Leung, J. (2006). *A review of the literature on transportation and economic development*. Retrieved from
- Levinson, D. (2005). The evolution of transport networks. In D. Hensher (Ed.), *Handbook 6: Transport strategy, policy and institutions* (pp. 175-188). Oxford: Elsevier.
- Levinson, M. (2006). *The Box. How the shipping container made the world smaller and the world economy bigger*. Princeton: Princeton University Press.
- Levinson, M. (2008). Freight pain: thre rise and fall of globalization (Essay). *Foriegn Affairs*, 87.6 (Nov-Dec 2008)(133(8)), 5.
- Lodish, H., Berk, A., Kaiser, C., Krieger, M., Bretcher, A., Ploegh, H., . . . Scott, M. (2014). *Molecular Cell Biology*. New York: W.H. Freeman and Company.
- Lotka, A. J. (1922). Contribution to the energetics of evolution. *Biology*, 8, 6.
- Lotka, A. J. (1989). Lotka on population study, ecology, and evolution. *Population and development journal*, 15(3), 539-550.
- Luhmman, N. (1990). *Political theory and the welfare state*. Berlin: de Gruyter.
- Mackie, H., Baas, P., & Manz, H. (2006). *The contestability of New Zealand's road freight task by rail*. Retrieved from

- Mackie, H., Baas, P., & Manz, H. (2006). *Prediction of New Zealand's freight growth by 2020*. Retrieved from
- Margulis, L. (1967). On the origin of mitosing cells (Writing as Lynn Saga). *Journal of theoretical biology*, 14(1967), 225-274.
- Marijuan, P. (2009). The advancement of information science: Is it a new way of thinking necessary? *TripleC*, 7(2), 369-375.
- Marijuan, P., Navarro, J., & Del Moral, R. (2015). How the living is in the world: An inquiry into the informational choreographies of life. *Progress in biophysics, and molecular biology*, 119(3), 469-480.
- Markovich, J., & Lucas, K. (2011). *The social and distributional impacts of transport: A literature review*. Retrieved from Oxford:
- Martenson, C. (2011). Transcript for Nate Hagens: We're not facing a shortage of energy, but a longage of expectation. *Chrismartenson.com*.
- Martin, W., Souza, F., & Lane, N. (2014). Energy at life's origin. *Science*, 244(6188), 1092-1093.
- Maxwell, N. (2009). *What is wrong with science?* (2nd ed.). London: Pentire Press.
- McGlone. (2006). What is the explanatory value of a conceptual metaphor? *Language and communication*, 27(2007), 109-126.
- McKinnon. (2006). The decoupling of road freight transport and economic growth trends in the K: An exploratory analysis. *Transport Reviews*, 36.
- Meade, R., & Evans, L. (2015). *Spectrum of regulatory responses: Foundation paper for the Regulation 2025 strategy project*. Wellington: NZ Government.
- Meadows, D. H., Meadows, D. L., Randers, J., & Behrens, W. W. I. (1972). *Limits to growth*. New York: Universe Books.
- MED. (2010). *Draft New Zealand Energy Strategy: Developing our energy potential*. Retrieved from Wellington:
- Mellman, I. (2008). George E Palade, Cell biology and the JBC. *Cell Biology*, 183(3).
- Monahan, P. (2016). These bacteria are actually tiny eyeballs. *Science*.
- Monbiot, G. (2016, 15 April 2016). Neoliberalism -the ideology at the root of all our problems. *The Guardian*.
- Morrow, K. J., & Smith-Morrow, J. A. (2008). Switzerland and the 2,000-watt society. *Sustainability*, 1(1), 32-33.
- MOT. (2008). *The New Zealand Transport Strategy 2008*. Wellington: New Zealand Government.
- Muller, M. (2015). Assemblates and actor-networks: Rethinking socio-material power, politics and space. *Geography Compass*, 9(1), 24-41.

- Navarro, J., Goni-Moreno, A., & Marijuan, P. (2010). Varieties of biological information: A molecular recognition approach to systems biology and bioinformatics. *International Journal "Information technologies and knowledge, 4(1)*, 56-66.
- Navarro, J., & Marijuan, P. (2011). How a bacillus "sees" the world: Information needs and signalling resources of *Mycobacterium Tuberculosis*. *TripleC, 9(2)*, 396-403.
- Nixon, C. (2010). *Freight Futures: Long term sea freight scenarios*. Retrieved from Wellington:
- Notteboom, T., & Rodrigue, J. (2008). The future of containerisation: perspectives from maritime and inland freight distribution. *GeoJournal(74)*, 7-22.
- NZ Government. (2008). *Government Policy Statement on Land Transport Funding 2009/10 - 2018/19*. Wellington: Ministry of Transport.
- O'Brien, W. (2008). The transport infrastructure in New Zealand: A critique: William O'brien.
- Odum, E. C., Scott, G., & Odum, H. T. (1979). *Energy and environment in New Zealand*. Christchurch: Joint centre for environmental sciences.
- Odum, H. T. (1956). Primary production in flowing waters. *Limnology and Oceanography, 1(2 (April 1956))*, 102-117.
- Odum, H. T. (1971). *Environment Power and Society*: John Wiley & Sons.
- Odum, H. T. (1973). Energy, ecology, and economics. *Ambio, 2(6)*, 220-227.
- Odum, H. T. (1974). Energy, ecology and economics. *Royal Swedish academy of science AMBIO, 2(6)*, 8.
- Odum, H. T. (1987). *Living with complexity*: The Swedish Academy of Sciences.
- Odum, H. T. (1994). *Ecological and general systems. An introduction to systems ecology* (2 ed.). University of Colorado: University Press of Colorado.
- Odum, H. T. (1995). Self organisation and maximum power. In C. A. S. Hall (Ed.), *Maximum Power*. Niwot: University of Colorado.
- Odum, H. T. (1996a). *Environmental accounting: Energy and environmental decision making*: John Wiley & Sons.
- Odum, H. T. (1996b). Scales of ecological engineering. *Ecological Engineering, 6 (1996)*, 7-19.
- Odum, H. T. (2007). *Environment, Power and Society: For the twenty-first century. The hierarchy of energy*. New York: Columbia University Press.
- Odum, H. T., & Odum, E. C. (1976). *Energy basis for man and nature*. New York: McGraw-Hill.
- Odum, H. T., & Odum, E. C. (1979). *Energy systems of New Zealand and the use of embodied energy for evaluating benefits of international trade*. Paper presented at the Proceedings of the Energy Modelling Symposium, Wellington.

- Odum, H. T., & Odum, E. C. (2001). *A prosperous way down: principles and policies*. Colorado: University Press of Colorado.
- OECD. (2011). *Key messages from ministers. 2011 Annual Summit: Transport for society*. Paper presented at the International Transport Forum, Leipzig.
- Offer, A. (2006). *The challenge of affluence: Self-control and well-being in the United States and Britain since 1950*. Oxford: Oxford University Press.
- Offer, A. (2007). A vision of prosperity.
- Opening the field of intracellular protein traffic. (2016). Retrieved from http://centennial.rucare.org/index.php?page=protein_translocation
- Oxford. (Ed.) (2000) *The Oxford compact english dictionary*. Oxford: Oxford University Press.
- Packer, G. (2013). *The unwinding: An inner history of the new America*: Faber.
- Paling, R. (2008). *National Freight Demands Study*. Retrieved from Wellington:
- Paling, R., & King, M. (2014). *National Freight Demand Study. March 2014*. Wellington: NZ Government Retrieved from <http://www.transport.govt.nz/assets/Uploads/Research/Documents/National-Freight-Demand-Study-Mar-2014.pdf>.
- Palmer, J. (2010). Bacteria can 'smell' their environment, research shows. *BBC News*.
- Parliament. (2010). *The next oil shock?* Retrieved from Wellington:
- Physiology or Medicine for 1999 - Press Release. (2014). [Press release]. Retrieved from http://www.nobelprize.org/nobel_prizes/medicine/laureates/1999/press.html
- Quine, W. (1960). *Word and object*. Cambridge: MIT Press.
- Reagan, R. (1985). Address to the Nation on Tax Reform (Vol. The American Presidency Project).
- Reddy, V., Kurian, M., & Ardakanian, R. (2015). *Life-cycle cost approach for management of environmental resources: A primer*. Cham, Heidelberg, New York, London: Springer.
- The Report: Saudi Arabia 2015*. (2015). Retrieved from
- Rittel, H. W. J., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4, 155-169.
- Robelius, F. (2007). *Giant Oil Fields - The highway to oil. Giant Oil Fields and their Importance for Future Oil Production*. Uppsala University, Uppsala.
- Robinson, A., & Austen, B. (1987). The role of topogenic sequences in the movement of proteins through membranes. *Biochemical Journal*, 246(2), 249-261. doi:10.1042/bj2460249
- Rodrigue, J. (2013). *The geography of transport systems*. New York: Routledge.
- Rodrigue, J., Comtis, C., & Slack, B. (2006). *The geography of transport systems*. New York: Routledge.

- Rubin, J. (2008). Coming home. *CIBC world markets*.
- Rubin, J. (2009). *Why your world is about to get a whole lot smaller*. London: Virgin Books.
- Sachs, J. (2008, 24 March 2008). Common wealth for a crowded planet. *Time*, 51, 5.
- Sachs, J. (2015). *The age of sustainable development*. New York: Columbia University Press.
- Savic, I., Berglund, H., Gulyas, B., & Roland, P. Smelling of Odorous Sex Hormone-like Compounds Causes Sex-Differentiated Hypothalamic Activations in Humans. *Neuron*, 31(4), 661-668. doi:10.1016/S0896-6273(01)00390-7
- Scheurgers, N., Lenn, T., R, K., Meissner, M., Esteves, T., Temerinac-Ott, M., . . . Wilde, A. (2016). Cyanobacteria use microoptics to sense light direction. *eLife*. Retrieved from <http://elifesciences.org/content/5/e12620v1> doi:5:e12620
- Schneider, E., & Kay, J. (1994). Life as a manifestation of the second law of thermodynamics. *Mathematical Computer Modelling*, 19(6-8), 25-48.
- Schrodinger, E. (1944). *What is life? The physical aspect of the living cell*. Dublin.
- Schuergers, N., Lenn, T., Kampmann, R., Meissner, M., & Esteves, T. (2016). Cyanobacteria use mirco-optics to sense light direction. *eLife*, 5(e12620). doi:10.7557/elif.12620
- Shell. (2006). Executive summary and excerpts. In v. d. Veer (Ed.), *Shell Global Scenarios to 2025*. London: The European Group.
- Sigismund, S., Confalonieri, S., Ciliberto, A., Polo, S., Scita, G., & Di Fiore, P. P. (2012). Endocytosis and Signaling: Cell Logistics Shape the Eukaryotic Cell Plan. *Physiological Reviews*, 92(1), 273-366. doi:10.1152/physrev.00005.2011
- Smil, V. (2003). *Energy at the crossroads*. Massachusetts: Massachusetts Institute of Technology.
- Soddy, F. (1912). *Matter and energy*. London: Williams and Norgate.
- Sojo, V., Pomiankowski, A., & Lane, N. (2014). A bioenergetic basis for membrane divergence in archaea and bacteria. *Plos Biology*, 12(8), 1-12.
- Solow. (1956). A contribution to the theory of economic growth. *The quarterly journal of economics*, 70(1), 65-94.
- Spencer, H. (1862). *First Principles*. London: William and Norgate.
- Staab, S., & Studer, R. (2009). *Handbook on ontologies*. Berlin Heidelberg: Springer-Verlag.
- Swenson, R. (1991). Autocatakinetics, yes - autopoiesis, no: steps toward a unified theory of evolutionary ordering. *General Systems*, 21, 207-228.
- Swenson, R. (1997a). Autocatekinetics, evolution, and the law of maximum entropy production: A principled foundation toward the study of human ecology. *Advances in Human Ecology*, 6, 1-47.

- Swenson, R. (1997b). Thermodynamics, evolution, and behaviour. In G. Greenberg (Ed.), *Comparative Psychology. A handbook*.
- Swenson, R. (1998). Spontaneous order, evolution, and autocatakinetics: The nomological basis for the emergence of meaning. In G. Van de Vijver, S. N. Salthe, & M. Delpos (Eds.), *Evolutionary Systems: Biological and epistemological perspectives on selection and self organisation*: Kluwer Academic Publishers.
- Swenson, R. (1999). Epistemic ordering and the development of space-time: Intentionality as a universal entailment. *Semiotica*, 127(1), 567-597.
- Swenson, R. (2000). Spontaneous order, autocatakinetic closure, and the development of space-time. *Annals of the New York Academy of sciences*, 901(January 2000), 311-319.
- Swenson, R. (2010). Selection is entailed by self-organisation and natural selection is a special case. *Biological Theory*, 5(2), 167-181.
- Swenson, R., & Turvey, M. T. (1991). Thermodynamic reasons for perception-action cycles. *Ecological Psychology*, 3(4), 317-348.
- Taleb, N. N. (2008). *The fourth quadrant: A map of the limits of statistics*. Retrieved from
- Tapio, P. (2004). Towards a theory of decoupling: degrees of decoupling? *Transport Policy*.
- Thatcher, M. (1980). Press Conference for American correspondents in London [Press release]
- Tiffin, J., & Kissling, C. (2007). *Transport communications: understanding global networks enabling transport services (nets)*. London: Kogan Page Ltd.
- Torday, J., & Miller, W. (2016). Life is determined by its environment. *International Journal of Astrobiology*, 15(4).
- Transport, M. o. (2015). *Freight and the transport industry: Freight volume*. Retrieved from Wellington:
- Upton, J. (2008). *Key factors that influence freight movements*. Auckland: TERNZ.
- van de Vijver, G., Salthe, S. N., & Delpos, M. (1998). *Evolutionary systems: biological and epistemological perspectives on selection and self-organization*: Kluwer Academic.
- Villanueva (Producer). (2013). Demand, supply and market equilibrium. *Economy & finance*. Retrieved from <http://www.slideshare.net/ChristianVillanueva/supply-demand-and-equilibrium>
- Wan, P. Y. (2011). *Reframing the Social: Emergentist systemism and social theory*. Surrey: Ashgate Publishing Limited.
- Warr, B., Schandl, H., & Ayres, R. (2008). Long term trends in resource exergy consumption and useful work supplies in the UK, 1900 to 2000. *Ecological Economics*, 68, 126-140.

- Watercare. (2016). Watercare Projects [Press release]. Retrieved from <http://watercare.maps.arcgis.com/apps/MapTour/index.html?appid=09d65590ff484e85bc7020db1c4a56d7#>
- Webb, J. (2016). Bacteria 'see' like tiny eyeballs. *BBC News*.
- Wells, C. (2001). *Total energy indicators of agricultural sustainability: Dairy farming case study*. Retrieved from Dunedin:
- Werrell, C., & Femia, F. (2017). *Epicenters of climate and security: the new geostrategic landscape of the anthropocene*. Retrieved from
- White, R., Engelen, G., & Uljee, I. (2015). *Modeling cities and regions as complex systems. From theory to planning applications*. Massachusetts: The MIT Press.
- Williams, P., Winzer, K., Chan, W., & Camara, M. (2007). Look who's talking: communication and quorum sensing in the bacterial world. *Philosophical Transactions of the Royal Society B-Biological Sciences*, 362, 119-1134.
- Williamson, M. (1996). *National Land Transport Strategy*. Retrieved from www.behive.govt.nz/national+land+strategy.
- Wilson, E. O. (2012). *The social conquest of earth*. New York: Liveright Publishing Corporation.
- Wilson, M. (2007). *Supply chains behaving badly*. (PhD), Lincoln University, Christchurch.
- Wolchover, N. (2014). A new physics theory of life. *Quanta Magazine*.
- World Trade Report*. (2007). Retrieved from Geneva:
- WWF. (2010). New report 'demands a rethink on oil'.
- Zierath, J. (2013). *Machinery regulating vesicle traffic, a major transport system in our cells*. Retrieved from The Nobel assembly at Karolinska Institutet