THE USE OF INFORMATION CONCEPTS IN THE DIALOGUE BETWEEN SCIENCE AND THEOLOGY

by

MARIO ALPHONSO MARAIS

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by Mario A. Marais

Summary

We are living in the information age and this has had an effect on both science and theology. Our understanding of the fundamental role of information has increased significantly. One can even say that information has become an overarching metaphor in the world of science. This dissertation gives an overview of the impact of the information-based scientific world-view on the dialogue between science and theology. The study investigates the metaphorical use of information concepts to secure a better understanding of God's action in the world and the role that information plays in the processes of life. The focus is on the role of biological information, and its relation to divine action is investigated. The scientific importance of information and the possible impact of information concepts on the science and theology dialogue of the future are discussed.

Key Terms

information, biological information, metaphor, divine action, intelligent design, biosemiotics, Dembski, Shannon, Gitt, Davies.

1 Introduction

We are living in the information age. In fact, we might say that we are swimming (or drowning) in a sea of information. According to Tom Siegfried (2000:44-45), we are now at the point where 'the computer ... has clearly become society's dominant machine, and information has become science's favourite superparadigm'. His so-called 'cartoon history' of modern science states that we have moved from the *clock/force era* (in which the clock was the dominant tool in society and force was the metaphor for the scientific world-view), through the *steam engine/energy era* (in which the steam engine was the tool and energy was the metaphor), and we are now in the *computer/information era* (in which information is the current metaphor of choice for the scientific world-view) (Siegfried 2000:45).

In addition, there has also been an increase in our understanding of the fundamental aspects of reality. Our sense of wonder has grown as scientists have discovered "deep" connections between what were thought to be disconnected ways of understanding the world. Recently, the concept of information has emerged as a very important, fundamental way of connecting quantum mechanics, computational theory, complexity theory and evolution. According to David Deutsch (1998:28), the four main strands from which our understanding of the 'fabric of reality' is composed are: quantum theory, the theory of evolution, epistemology and the theory of computation. His view is that 'the four of them taken together form a coherent explanatory structure that is so far-reaching, and has come to encompass so much of our understanding of the world, that in my view it may already properly be called the first real Theory of Everything' (Deutsch 1998:28-29). As a result, we have seen the growth of the field of quantum computation, which has also provided an important stimulus to the study of the fundamental role of information.

These new ways of thinking about the fabric of reality and the fact that information may be the dominant paradigm of our age have also had an effect on the dialogue between science and theology. Information has been used in many areas and in many ways. Information concepts have been used metaphorically to try to shed new light on topics such as the nature of God, divine action, revelation, etc. Information is a complex topic and this dissertation starts with an overview of the different contexts or roots of information. It then covers the 'hard' science side of the dialogue by examining divine action, specifically biological information, which is the new active area. The general question of how information concepts are used in the dialogue between science and theology is then surveyed, with the main focus being on how to bridge the gap between science and theology through the metaphorical use of information concepts. The different points of departure of the participants in the science and theology dialogue are discussed within the framework of Ian Barbour's typology of the relationship between science and theology. In conclusion, the possible roles of information concepts in the unfolding dialogue between science and theology are discussed.

2 Putting information into perspective

2.1 The scientific roots of information

2.1.1 Shannon's information theory

The birth of a formal theory of information is usually traced to research done into communications at Bell Laboratories in the 1920s. Ralph Hartley was the first to propose a measure for the amount of information in a message in 1927 (Brown 2000:42). Claude Shannon extended Hartley's idea of using the logarithm of the total number of possible messages by including the probability of any one message (Brown 2000:43). Shannon's ideas were first presented in an article entitled: "A mathematical theory of communication" which was included in a book published in 1949 (Shannon & Weaver).

Shannon's formula (Brown 2000:43) can be expressed as:

information = - log (probability) where we are referring to a base 2 logarithm[1].

If a message is very unlikely (as in a string of random letters, abfjlsfgahek....), then the information content is high. If the message has a high probability (as in the same letter repeated many times, aaaaaaaa....), then the information content is low. Note that nothing is said about meaning at all.

The probability of the message will vary between 0 and 1. The logarithm will therefore vary between minus infinity ($2^{-\infty} = 1/2^{\infty} = 0$) and 0 ($2^0 = 1$). The negative sign thus ensures that information is always reported as a positive number between ∞ and 0. A very unlikely message will therefore have a very large "information content number"[2].

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[1] The base 2 logarithm of $2^x = x$ or $\log(2^x) = x$. So the base 2 logarithm of 8, which is 2^3, is 3.

[2] Let us assume that the probability of a message is 1 in 1024. Now $1024 = 2^{10}$, so the probability = $1/1024 = 1/2^{10} = 2^{-10}$. The base 2 logarithm of 2^{-10} is $\log(2^{-10}) = -10$. The information content is then $-(-10) = 10$.

In computer terms we refer to something called a "bit" (binary digit), which is derived from the binary (base 2) number system. For example, decimal 2 is represented as **10** ($1 \times 2^1 + 0 \times 2^0$)[3]. Flipping a coin is the usual way of explaining probability and bits (Siegfried 2000:2). A coin can land with either heads or tails up. There are therefore two, equally likely possibilities. These can be represented by the 0 and the 1 of the binary system, which is referred to as one bit. One bit is the information that is required to distinguish between the two equal possibilities (Siegfried 2000:65). If we were picking out a single word from a dictionary with eight words, (2^3) then we would need three bits to convey the information content, that is which word was selected out of the eight possibilities. For an extensive discussion of information theory, refer to Gitt (1997:170 –178).

2.1.2 The link with entropy

From the outset the connection between Shannon's measure of information and entropy (the thermodynamic measure of disorder) was proposed. Shannon also terms his measure entropy[4] in order to bring out the similarity in formulation (Siegfried 2000:65, Brown 2000:45).

Boltzmann's definition of entropy is really a measure of statistical disorder, where one looks at the fact that there are more possible disordered states than ordered states and hence the probability of a system being in an ordered state is low. Systems are therefore more likely to be in a disordered state. An observer can discover less about a disordered state, and in that sense it has less information than an ordered state. According to Brown (2000:45), Boltzmann also saw entropy as a 'form of missing information'.

It is not certain that there is a deep connection between information and thermodynamic entropy. People have argued that 'the utility of equivalent

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[3] In the base 10 we system we normally use, **10** stands for ($1 \times 10^1 + 0 \times 10^0$) = 10+ 0 = 10.

[4] Entropy, a measure of disorder, is linked to the famous second law of thermodynamics which states that the total amount of entropy of a closed system can never decrease. Boltzmann's formula $S = k \log W$ expresses the entropy S as a measure of atomic disorder, where W is the probability of a certain state. k is Boltzmann's constant (Brown 2000:44).

mathematical formulas in thermodynamics and communication theory has no more significance than, say, the general utility of the Gaussian normal distribution[5] ... in a wide variety of disciplines' (Harms 1998:478). Harms (:479) goes on to point out that the reason that entropy can be used as an information measure is because mathematically it satisfies the intuitive requirements for a measure of uncertainty. However, new developments have led some people, such as Tom Siegfried (2000:66), to feel that the time has now come to state: 'The physicist's entropy and Shannon's entropy are two sides of a coin'. According to him, this deep connection has been made via studies of the physics of computation and the study of information processing, which has 'solidified the conclusion that information is more than a metaphor' (:66). Brown (2000:45) makes a similar case that studies of the physics of computation, in particular that of the issue of the energy consumed in computation, have revealed deep connections between 'knowledge and physics'. In fact, to Siegfried (2000:66), 'one of the deepest and most important while least appreciated and least understood discoveries of modern science' is: "information is physical"'.

This line of thinking has been extended by Ed Friedken, who views the universe as 'a gigantic digital computer processing information' (Brown 2000:59).

Roy Frieden (1998) has pointed out the importance of another measure of indeterminacy that is related to entropy, namely *Fisher information*. Frieden (:2-3) has developed a theory of physical law, called Extreme Physical Information (EPI) which is an expression of the 'inability to know' a measured quantity (:2-3). This 'inability to know', or the quality of any measurement, can be specified by a form of information known as Fisher information (:1). The fundamental issue is that physics quantifies phenomena that are observed and that, as a part of this exercise, physics also defines the fluctuations or errors from the ideal values that occur (:2-3). Physics defines the laws of physical fluctuations and Fisher information is the quantitative measure of physical fluctuations (:3). This means that Fisher information is 'intrinsically tied into the laws of fluctuation that define theoretical physics' (:3). It is

[5] The Gaussian normal distribution refers to a particular way that errors are distributed about a mean. It is named after the famous German mathematician, Karl Friedrich Gauss (1777-1855) (Reader's Digest Great Encyclopaedic Dictionary 1964).

also the measure of the state of disorder of a system and hence is related to entropy. The overall message is that information is fundamental to how we describe the world.

We will come back to this whole issue later[6]. First, we want to complete the picture regarding information by giving a brief overview of alternative and complementary formulations of information.

2.1.3 The different formulations of information

Siegfried (2000:175–176) compiled the following summary of the different ways of looking at the quantification of information:

Shannon entropy (or Shannon information)

The negative logarithm of the probability of a message i.e. a measure of uncertainty or freedom of choice in composing a message.

Algorithmic information content

(also called algorithmic complexity, Kolmogorov complexity or the Kolmogorov-Chaitin theory of algorithmic information)

The number of bits in the smallest program that outputs the message string when run on a universal Turing machine. It is dominated by randomness (see also Davies 2000:116-120, Cilliers 1998:9-10). Randomness is defined by Chaitin not in terms of uncertainty, but in terms of incompressibility or of how densely the information is packed (Cilliers 1998:9). We can therefore say that this is a measure of complexity in terms of denseness of information.

Logical depth

The number of steps in a deductive or causal path connecting a thing with its plausible origin, or the time required by a universal computer to compute the object in question from a program that could not itself have been computed from a more concise program; a measure of organisation.

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[6] Entropy is discussed again in Subsection 5.6.7.3: *Wheeler's 'It from Bit'*.

Statistical complexity

The amount of memory in bits required for a machine or agent to predict its environment at a given level of accuracy, or the minimum amount of historical information required for optimal forecasts of bits in an object at a specified error rate; a measure of structure.

In addition, we can go back to the origins of the word 'information'.

In Latin we have (Collins Latin Dictionary plus Grammar 1997):

- informatio, informationis - sketch, idea
- *informis* (adjective) - shapeless; hideous
- *informo, informare, informavi, informatum* (transitive verb) - to shape, fashion; to sketch; to educate.
- *forma, formae* - form, shape, appearance; mould, stamp, last; (person) beauty; (figurative) idea, nature, kind.

John Puddefoot (1996:302) mentions the German *informieren* and the French *informer* as well.

These meanings of the term have been used to view the fundamental meaning of information as being the act or result of informing (Van der Lubbe & Laurent 1992:87). Harms (1998:497) regards the original meaning of 'to inform' someone as being to give form to his or her mind, in other words to teach.

To summarise, we can turn to John Puddefoot's fundamental threefold distinction between the ways in which the term 'information' is used (1996:302):

- *Counting information* includes all the mathematical forms of information, with the focus on various measures of information (as we have indicated above - Shannon information, algorithmic information content, logical depth and statistical complexity).

- *Meaning information* is information in its normal everyday meaning, namely information in the sense of imparting knowledge, which is largely dependent on language and culture (see the next section on communication).
- *Shaping information* denotes information as a noun, describing the action of giving form to something.

From the perspective of a person interpreting information, we can tie together all the uses of the term by stating that counting information is the basic raw input that must give form to our minds, thus informing us in the sense of shaping information, and thereby conveying meaning information to us (Peacocke 1996:326, Puddefoot 1996:312).

2.2 The human roots of information - the wide world of information

2.2.1 Introduction to the theory of communication

The study of all the varied processes of communication between humans, and between humans and animals, is called the 'theory of communication' (Fauconnier 1987:11). The theory of communication is a multi-disciplinary study that derives concepts and views from the other sciences which it tries to 'assimilate to form a coherent whole' (:11).

The scientific research field of communication theory varies greatly and can include one or more of the following branches (Fauconnier 1987:23):

- Communication processes in general: human, animal, mechanical (technical)
- Human communication
- Animal communication: zoosemiotics, ethology
- Technical communication: electronics, cybernetics, data processing, informatics, telecommunication
- Biochemical communication: genetic information, the study of DNA, cellular communication
- Neurophysiological communication: perception of stimuli, processing by the brain, the study of sense organs, etc.

2.2.2 What is communication?

Due to the multi-disciplinary nature of this field of study, it should come as no surprise that there are at least 160 definitions of communication (Fauconnier 1987:28). Fauconnier (:31-36) finds four basic points of distinction in the definitions, namely:

- the **observation level** (Are we dealing with communication in general or just human communication?)
- the **intentionality** of the source (for example, a teleological view focuses on the source's intention of having the message received, whereas the behavioural view is that all behaviour is communicative)
- **normative judgment** (Did the communication succeed or not? Was a certain idea elicited in the mind of the interpreter?)
- the **direction** of the communication process (uni-directional or bi-directional).

In addition, Stappers distinguishes six types or categories of definitions (as quoted by Fauconnier 1987:36-38):

- Emphasis on the **recipient** (who selects from the unlimited number of messages coming in)
- Emphasis on the **source** (the intention of the source to influence the recipient - the classic view)
- **Linking** (the partnership between source and recipient – the interaction is important)
- **Commonality** (the result of linking – the sharing and participation in each other's thoughts)
- **Transmission** (the channel through which the message is transmitted)
- Use of **symbols** (the importance of the encoding system – no thought possible without words?).

Fauconnier (1987:38) makes the point that the definitions are created in a certain scientific environment or *context* in which they are indeed useful for the purposes of that environment. The underlying issue is the *behavioural theory* that is being subscribed to. Positions range from extreme behaviourist through to interactionist and to phenomenological (:39-40).

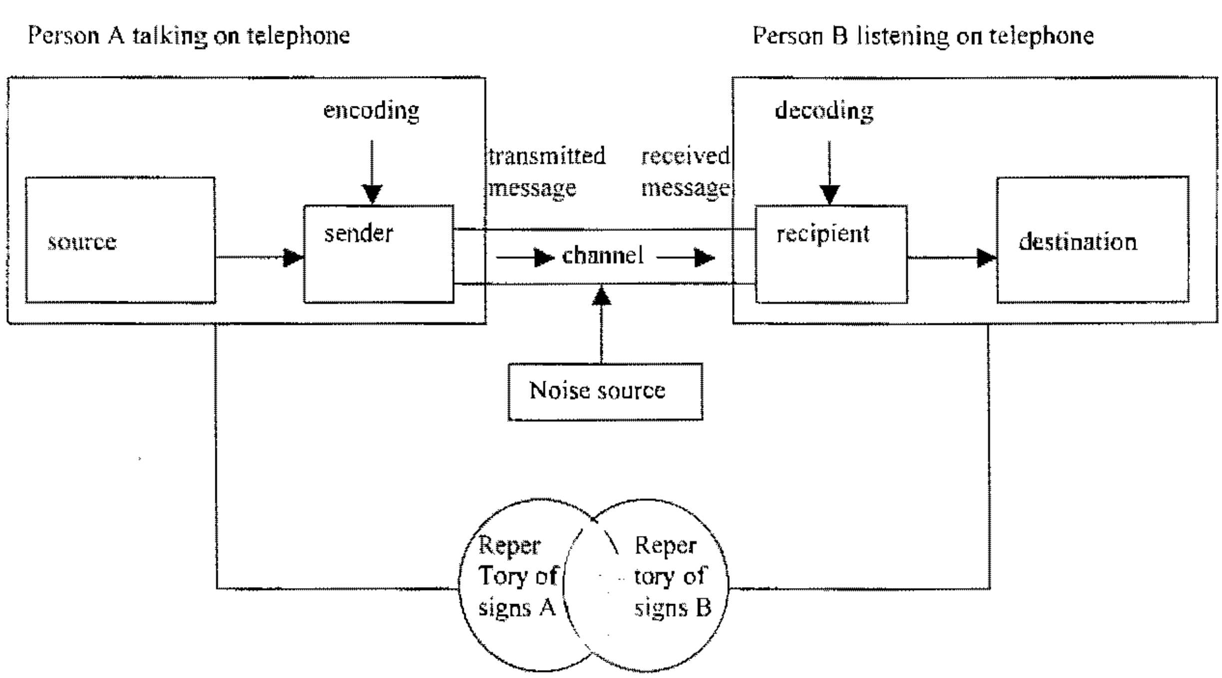
Being based on a broad behavioural-communicative view, Fauconnier's own definition of communication is as follows:

> From a general communication-theoretical point of view, human or social communication is a process in which a source tries to make data available to a recipient by means of a channel, signs and symbols, with the intention of letting the recipient process the data into information with a meaning intended by the source.
>
> (Fauconnier 1987:167).

In order to further clarify what is meant by communication, it is useful to investigate models of the communication process.

2.2.3 Models of communication processes

There are more than 50 models of the communication process (Fauconnier 1987:46). To illustrate the concepts involved, we will use the mechanistic Shannon-Weaver model as shown below (:42-46).



The context of this model is that of a telephone conversation. We can distinguish the following elements:

- A *source* and a *sender* (person A and the telephone handset)
- A *receiver* and a *destination* (the other telephone handset and person B)
- *Encoding* and *decoding* (converting the content of the mind into a code (based on signs) that can be transmitted, and the reverse process)
- *Repertory of signs* (the media) by which the message is carried. The source and the recipient each have their own repertory and these must partially correspond. Each sign combines the signifier and the signified.
- *Signals* (the arrows in the drawing) are the physical entities such as electromagnetic waves that are reconverted into signs when decoding takes place.
- The *channel* is the means by which the signs and signal are transmitted, e.g. copper wire or air.
- The *medium* is the object that carries the message or the technical medium that enables us to receive the message via our senses, e.g. television or radio.
- The *message* is that which is being expressed and transmitted - meaning, information, feelings, etc. A position that can be held is that data that is transmitted become information once it has been 'assimilated in the thought system' (:45).
- *Feedback* is what happens when the source gains information as a result of the communicative action.
- The *noise source* refers to signal noise that can occur in the channel, thus distorting the message.

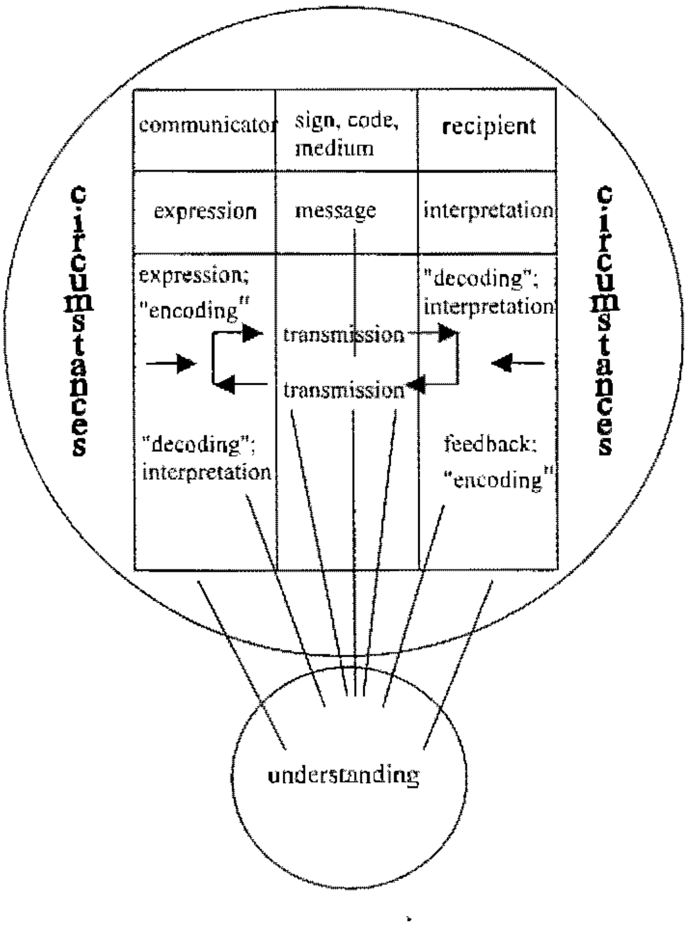
There are different perspectives on the communication process, resulting in different models, namely (Fauconnier 1987:46):

- *Structural or analytical models* that focus on the components or factors of the process and their relationships
- *Dynamic models* that focus on the evolution of movement of the process
- *Functional models* that show causal relationships and interactions

* *Operational models* that enable the prediction and measurement of communication.

The model of Shannon and Weaver as described above is an example of a graphic-dynamic model and is often used since it provides the simplest way of describing the communication process and introduces many of the concepts (Fauconnier 1987:58). One should, however, be careful in this IT (information technology) world that we live in, not to reduce the richness of the communication concepts to bits and bytes. For example, what we called the 'message' is quickly reduced to a focus on the data that is being transmitted. The point is that the data only become informative once it has been received and understood by the person it is communicated to. The role of the recipient in selecting which message to hear is also important.

In order to press this point home, we will look at the analytical communication model (see below) of M van Schoor which stresses the role of the recipient (Fauconnier 1987:55-57).



The focus in this model is on the communicator, the medium and the recipient. The communicator wants to send a message intended for a recipient and uses a medium, which is a combination of codes and signs. The recipient plays an active role because he or she is not just a termination point, but the turning point of the message, since the message could go back to the source. The potential value of the message is turned into real value by the recipient through interpretation. The essential characteristic of communication is intersubjectivity, i.e. the mutual understanding that develops. This presupposes that the communicator and the recipient have many things in common, such as language rules and social circumstances.

The four levels of the model represent (from the top):

- the *externally perceptible level* (we can see the communicator, the signs, the medium, etc.)
- the *inner dimension* in which the meaning of the message is expressed and interpreted
- the *performance level* at which the actions of encoding, delivery and decoding take place
- the *encompassing level* of the social circumstances in which this communication process takes place.

Finally, the diagram shows that the quest for mutual understanding is the core of all human communication.

The philosophical basis of van Schoor's model is that communication is the experience of reality or, as Fauconnier states, using Ortega y Gasset's terminology, 'it is a dialogue between man and his circumstances' (:57).

To sum up this overview of communication models:

- The communication process is too complex to be fully represented by a model. Issues such as personality, motives and other social variables play a role.
- By examining the explicit or implicit communication model that is being used, one can determine the point of departure of the researcher.

In the context of this dissertation, the following conclusion by Cronkhite is very important:

> Your choice of models will depend on what you want to look at, and what you see will be determined by the model you choose
>
> (as quoted by Fauconnier 1987:58).

If we now step back and look at the multi-disciplinary nature of the study of communication, we can distinguish five main points of view (Fauconnier 1987:89):

- a *psycho-philosophical* view of the relation between symbol, meaning and communication
- a *cybernetic systems-theoretical* view
- a *socio-psychological* view
- a *pragmatic* view
- a *symbolic-interactionist* view.

In the context of this study we do not need to cover these views in detail. The purpose is merely to ensure awareness of the richness and complexity of the study of communication. In the dialogue between science and theology, the mathematical or information theory-based approach, which forms part of the cybernetic systems-theoretical view, has tended to dominate.

We will now move to less familiar territory. We have discussed information in the traditional contexts of mathematics and physics, and human communication, but now we move to the biosphere and examine communication between all living things.

2.3 The biological roots of information - from biosphere to semiosphere

Jesper Hoffmeyer makes the fundamental point that with the emergence of life, we moved beyond the sphere of physics to the sphere of communication and interpretation (Hoffmeyer 1997). Emmeche and Hoffmeyer (1991) take issue with the trend in biology to use terms such as 'code' and 'information' borrowed from the mathematical theory of information (as formulated by Shannon). Their point is that these concepts are not unambiguous and when we talk of 'biological information' we are dealing with a concept of information that is understood as an 'objective quantifiable entity' (Emmeche & Hoffmeyer 1991:3). They make the point that this is not the same concept of information that we use in the context of human communication, in which we become informed via conversation and that we need a semantic level of analysis, not just the statistical analysis of information theory. Biological information, since it deals with teleonomic living systems, should also participate in this semantic or meaning dimension. Emmeche and Hoffmeyer admit that the cost of this is the abandonment of information as an *objective* quantity, measured in bits or genes, and a moving on to information as a *subjective* category. The definition of information that then becomes appropriate is that of Bateson, namely that information is taken to mean 'a difference that makes a difference to somebody' (Emmeche & Hoffmeyer 1991:4, Bateson 2000:315). This introduces the subject, without which information does not make sense. Information is something that is generated by a subject; it is always information *for* someone (an intentional creature) and it cannot be quantified into just bits and bytes (Hoffmeyer 1996: 65-66). Emmeche and Hoffmeyer's (1991:4) thesis is that 'living systems are real interpretants of information: they respond to *selected* differences in their surroundings'. This is the basis for the use of analogies from the context of human communication to understand the purposeful behaviour of living systems.

The point of departure here is that of describing the dynamics of living systems from the perspective of communication or the exchange of signs. The Greek word for sign is *semiosis* and the study of signs is called **semiotics**. This approach is therefore called **biosemiotics**, the study of living systems from a sign-theory perspective. Hoffmeyer goes on to define biosemiotics further by stating:

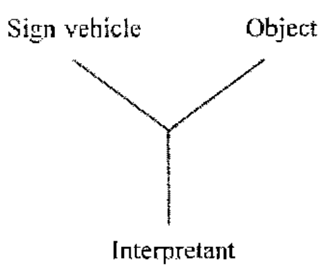
> In the biosemiotic vision natural entities and processes are seen as interconnected webs of relations, shaking hands so to say between levels in the hierarchical scale, stretching along the spatial dimension from the single cell to the biosphere or, along the semantic dimension, from pheromone-signalling to the human psycho-neuro-immuno-endochrine system.
>
> (Hoffmeyer 2000)

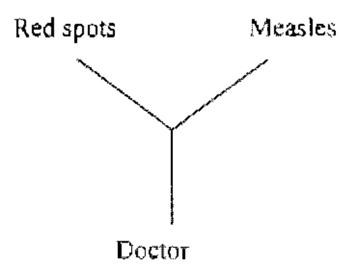
This view of nature is based on the theory of signs of Charles S Peirce and not on the other main semiotic tradition, namely the linguistic structuralism of Ferdinand de Saussure (Emmeche & Hoffmeyer 1991:4).

Peirce's logic is based on the fundamental assumption that three-factor relations (triads) are needed since two-factor relations are too limited to represent logical processes as a multi-dimensional network (Hoffmeyer 1996:17). The outcome is that a valid thought consists of the relation between three things, for example cause and effect and the observer who made the connection. Logic is intimately bound up with the idea that someone exists to make the inferences. Peirce regarded logic as the philosophy of communication and the science of the general laws of signs (:18). Peirce called his triad a **sign**, his logical theory **semiotics** and the process by which signs are exchanged, the functioning of signs, **semiosis**. The definition of a sign is that it represents a relation between three factors, namely:

- the primary sign or the sign vehicle
- the object to which the primary sign refers
- the interpretant - the system that creates the relationship between the primary sign and the object (:19).

This may be represented as follows:

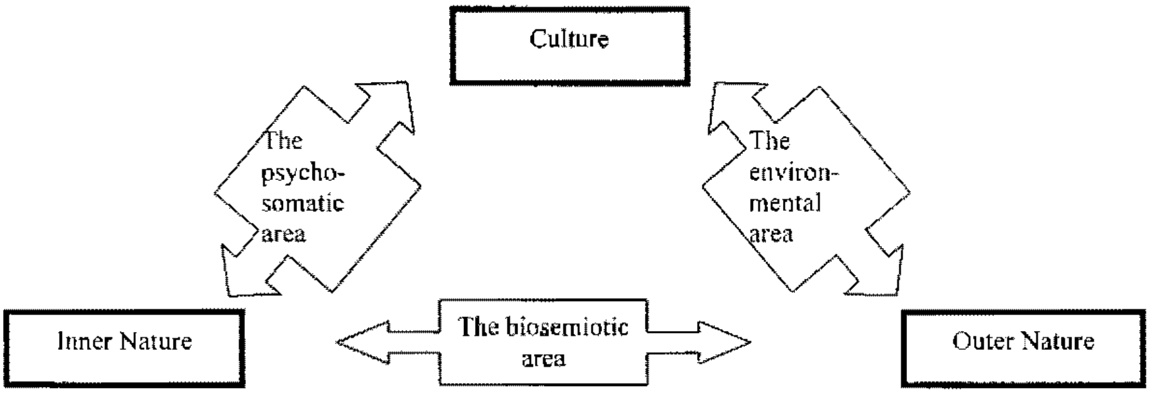




Hoffmeyer (1996:19) gives the example (shown above) of red spots (the sign vehicle) which are associated with measles and are interpreted by the doctor via a mental process.

The semiotic approach deals with two metaphors: nature-as-language and life-as-language. The world is seen as 'a universal language instead of a giant clockwork' (Turbayne as quoted by Emmeche & Hoffmeyer 1991:27). Life is seen as a sign-relation network rather than an information-processing machine (Hoffmeyer 1996:37). All organisms live in a world of signification (:vii). The semiotic network between creatures participating in semiosis constitutes an emergent level, which is called the **semiosphere** (:58-59). Our description of the world now includes a semiosphere in which the biosphere is immersed. The semiosphere 'penetrates to every corner of the other spheres, incorporating all forms of communication: sounds, smells, movements, colours, shapes, electrical fields, thermal radiation, waves of all kinds, chemical signals, touching, and so on. In short, all signs of life' (:vii).

Hoffmeyer (1996:96) uses the following model:



The biosemiotic area is seen as 'the mediator between man's outer and inner natures and, hence, between culture and nature' (:96). With the biosemiotic approach to biology, biology becomes a meeting place between physics and the humanities (Hoffmeyer 1997). We can represent an overview of the levels of information as follows:

People	Human communications	The semiosphere
Organisms	Cells talking to cells - exchanging signs	
Atoms	Physics of information	

3 A brief overview of the divine action debate

3.1 Why is this debate important?

Simply by framing this question: 'How does God act in the world?', we have made many assumptions, the most important being that such a thing as a God exists and that he/she/it is capable of acting on the world in some fashion.

Why should we ask this question? According to Moltmann (1995:207), the question of 'God's action/interaction with the world' is embedded into a larger context of a theistic model of God. A whole host of questions are related to this question:

- What are the prospects of natural theology?
- What about the 'God of the gaps' problem?
- God must make a difference if I am to believe. Who would believe in a powerless God?
- What world-view and what view of God lie behind the last question?

Some of these questions were addressed in a series of conferences, sponsored by the *Vatican Observatory*, on the topic of God's action in the world in the light of recent developments in science. The purpose of the conferences was to further investigation into the possible relations between religion and science. The particular topic of God's action was chosen because:

- The question of how God acts is at the heart of many conflicts between science and Christianity.
- Different views of divine action have had a great deal to do with creating the differences between liberal and conservative views of theology.
- This issue is the point at which modern science has had its greatest impact on theology in the modern period (Murphy 1997:33, 66).

Wildman (1996:54) states that the problem of divine action is 'one issue in need of a breakthrough' and that 'very little of major consequence has changed in the shape of this problem'. Polkinghorne's (1996:41) opinion is that the issue of divine action remains at the top of the agenda for science and faith discussions.

Peacocke (1993:150) says that 'without some plausible (certainly not mechanistic) account of how God might interact with the causal nexus of individual events in the world, including human-brains-in-human-bodies, we cannot with integrity assert that God does, or might, do so'.

Trigg (1998:79) asserts that we must face the full-blooded metaphysical question of whether science could in any circumstance accept the intervention of God. Peacocke, Barbour and Polkinghorne refuse to use the word 'intervention' and prefer to use the term 'interaction' for divine acts (Polkinghorne 1996:41). To Trigg (1998:125), 'the whole point of believing in God is that He is not "causally inert"'. For Trigg (206), religion concerns human relations with a God who is active and can enter into relations with people.

Bultmann's view is that the action of God is hidden from every eye, except the eye of faith (Trigg 1998:97).

Gregersen and Van Huyssteen (1998:80) make the point that what is at stake for theology in the dialogue between science and theology 'is whether or not it would be possible plausibly to revise the belief that God works out God's purposes in and through the processes of the natural world'.

3.2 Biological information - The new arena of the divine action debate

The focus of the science-theology debate has shifted away from cosmology to evolution and molecular biology. This has been due to our increasing understanding of the intricacies of life. The futurists are proclaiming that the information revolution is now being followed by the biological revolution. The synergy between these two revolutions will lead, and has led, to a real explosion in our scientific understanding of the fundamentals of life. The decoding of the human genome in record time is evidence of this explosive synergy. The evidence is that this will remain the hot issue of our time and that, as new insights develop, new perspectives on the divine action debate will be opened. For now the concept of biological information is the specific area in which new insights are being developed, since old questions are being asked in a new language.

4 Three approaches to biological information

4.1 Introduction

In order to introduce the various concepts that are being used, we will discuss in some detail the contributions of Werner Gitt, Paul Davies and William Dembski, who cover different parts of the spectrum of approaches. Gitt is a young Earth creationist. Davies adopts a carefully reasoned stance, which is somewhat outside the boundaries of 'hard science'. Dembski is a prominent member of the Intelligent Design movement, which believes that the presence of design can be proved scientifically, but does not demand a literal interpretation of the Bible in terms of six days of creation.

We start with Werner Gitt's work since he has given the most complete overview of all aspects of information and has worked out the most comprehensive system of laws.

4.2 Werner Gitt

4.2.1 Introduction

Prof Dr-Ing Werner Gitt is an information scientist at the German Federal Institute of Physics and Technology. He is also a Christian who has written many books and has lectured widely on the topic of 'Faith and Science' in many countries, including South Africa. Professor Gitt believes strongly that God created the world in a week (Gitt 1997:162), and dismisses theistic evolution theories in his book *Did God Use Evolution?* (Gitt 1993). In this dissertation we want to discuss the full exposition of his ideas on information and its usefulness in supporting his position against evolutionists, as captured in the book *In the Beginning was Information*.

4.2.2 Gitt on information

The purpose of the book is to 'help uproot the current evolutionary paradigm' (Gitt 1997:24) and show that we need to involve God as the creator, as 'the Person Who is the Prime Cause' (:10), in order to explain the origins of life. This is made abundantly clear by the title of the book as well.

In order to achieve his two objectives, Gitt (1997:9) focuses on information:

Because information is required for all life processes, it can be stated unequivocally that information is an essential characteristic of all life. All efforts to explain life processes in terms of physics and chemistry only, will always be unsuccessful. This is the fundamental problem confronting present-day biology, which is based on evolution.

Gitt (1997:9) considers information to be a 'fundamental entity on equal footing with matter and energy'.

The method used is to formulate natural laws of information which are then used to 'develop an alternate model which refutes the doctrine of evolution' by showing how evolutionary theory violates these laws (Gitt 1997:10).

4.2.3 Gitt's description of the scientific approach

In a chapter called 'Principles of laws of nature', Gitt (1997:22) formulates the scientific method as being: observing the world, followed by organising the observations systematically, and finally, deriving principles that are formulated in the most general manner possible. Gitt (:22) stresses that the scope of science is limited: 'Questions about the origin of the world and of life, as well as ethical questions, fall outside the scope of science, and such questions cannot be answered scientifically'.

Within the domain of science, Gitt (:22) makes clear that the outputs of the scientific method have varying degrees of certainty. He develops a classification scheme based on the degree of certainty. The degree of certainty is determined by evaluating the degree of testing to which a statement about natural events has been subjected. The most certain statements are the laws of nature which have been 'verified repeatedly in a reproducible way so that they are regarded as generally valid' (Gitt 1997:22). According to Gitt (:22), statements about natural events can be arranged according to decreasing degrees of certainty as follows:

- Law of Nature

- Model
- Theory (Greek *theoria* = a view, consideration, investigation)
- Hypothesis (Greek *hypóthesis* = assumption, conjecture, supposition)
- Paradigm (Greek *parádeigma* = example, sample)
- Speculation
- Fiction.

In his discussion of hypotheses, Gitt (:23) raises the issues of falsification (one fact can cause rejection of a hypothesis) and later (:24) the issue of verification (theories must be experimentally verifiable).

It is especially interesting to focus on Gitt's definition of a paradigm and to reflect on the position that it occupies in this hierarchy. Gitt's (:23-24) definition of a paradigm is as follows:

> Paradigm (Greek *parádeigma*: example, sample): When a certain theory (or a system of hypotheses, or a world-view) pervades entire fields of research or an entire scientific era, it is known as a paradigm. Such a view then dictates the scope for specific researches and delineates the presuppositions used for explaining individual phenomena. If a system of hypotheses has been derived from presuppositions dictated by a world-view, it usually cannot be reconciled with the available facts. A typical example is geocentricity (refuted by Copernicus)....It is hoped that this book will help to uproot the current evolutionary paradigm.

Gitt raises the issue of the influence of a 'world-view' here, with the intent of attacking the 'evolutionary paradigm' which is derived from a certain world-view as he sees it.

Having established the varying degrees of certainty, Gitt (:25) goes on to attack the absolute certainty with which statements are formulated. I presume that this is aimed at some of Richard Dawkins' pronouncements. Gitt (:25) quotes Max Born, a physicist and Nobel laureate:

> Ideas like absolute correctness, absolute accuracy, final truth, etc. are illusions which have no place in any science. With one's restricted knowledge of the present situation, one may express conjectures and expectations about the future in terms of probabilities. In terms of the underlying theory any probabilistic statement is neither true nor false. This liberation of thought seems to me to be the greatest blessing accorded us by present-day science.

Gitt (1997:25-26) goes on to make the point, via further quotations that refer to Thomas Kuhn's well-known work on research paradigms, that paradigms are persistent and lead to people actually explaining observations in such a manner that they fit the established theory instead of (possibly?) correcting or falsifying it. With time, this effect becomes worse. As Gitt (:26) phrases it: 'The persistence of a paradigm which has survived the onslaught of reality for a long time, is even greater'.

It is interesting that Gitt uses the phrase 'onslaught of reality'...as if reality itself, 'pure' observations', rather than the people who are making these, possibly biased, observations about reality are involved.

To Gitt a fixed yardstick or corrective remains essential. He states (1997:26): 'A minimal requirement for testing whether a theory should be retained, or whether a hypothesis should not yet be discarded, or that a process could really work, is that the relevant laws of nature should not be violated.' The ultimate 'paradigm-breaker' is the laws of nature.

Gitt spells out the special properties of the laws of nature via nine theorems. The laws of nature are (Gitt 1997: 26-32):

1. based on experience (and thus are empirical statements that cannot be proved, but 'they are nevertheless valid' (:27))
2. universally valid
3. equally valid for living beings and for inanimate matter
4. not restricted to any one field of study
5. immutable
6. simple
7. (in principle) falsifiable.

Furthermore, the laws of nature:

8. can be expressed in various ways
9. describe reproducible results.

These nine theorems have been 'derived from experience' and 'their correctness cannot be proved, but can be tested repeatedly in the real world.' (Gitt 1997: 33). Gitt (:33) now goes on to formulate a tenth theorem which 'depends on the personal view of the user' and hence he gives two different versions:

10a. Natural events can be explained without God.
10b. The present laws of nature became operational when creation was completed.

Although Gitt (1997:33) does acknowledge that 'both views are equally a question of belief and conviction', he goes on to take up the position that we can decide which view is more useful to us. In his further arguments, the type of usefulness he is referring to seems to be related to what makes sense.

Gitt (1997:33) bases theorem 10b on Genesis 2:2 and his interpretation of the creation narrative is that the laws of nature were 'installed during the six creation days', hence the laws only became active by the seventh day of creation. This then means that one cannot explain creation, including the origin of life, in terms of the laws of nature, since all life was created *before* the laws became active (:33-34).

Gitt (1997:34) also makes the following strong claim: 'The moment that historical questions (e.g. about the origin of the world and of life) or future events (like the end of the earth) are considered, then N10a [Theorem 10a] is entirely useless.' This might be based on his standpoint that God, being the Creator of the laws of nature, has absolute control and is not limited by laws (:34). This means that God has absolute control over both the past and the future and it is fruitless to consider just the possibilities due to the effects of the laws of nature.

Having established a basic set of natural laws, Gitt (1997:40) derives a set of laws or theorems about information which, according to him, are also laws of nature and to which all the properties of natural laws apply.

4.2.4 Gitt's information laws

4.2.4.1 Introduction

Gitt makes a major classification of all aspects of information with 30 theorems or laws of information, five levels, two fundamental properties, three forms of information and three kinds of transmitted information.

Gitt's (1997:44) point of departure is that information is a fundamental quantity, at the same level as that of matter and energy. He (:44-45) goes on to show that Shannon's information theory[7] covers what he calls 'a very minor aspect of information', namely the statistical aspect. Shannon's theory does not deal with the contents of messages, only the statistical likelihood of a message. Gitt's goal is to bring in a new dimension with respect to information. He (:46) calls the assumption that information is a material phenomenon 'a fundamental fallacy' that has led to 'seriously erroneous conclusions'. Gitt (:46) quotes the father of cybernetics, Norbert Wiener: 'Information is information, neither matter nor energy. Any materialism which disregards this, will not survive one day.' Gitt (:46-47) produces further quotes which bring in the issue of meaning, the semantic aspect of information, which leads on to the questions regarding the senders and recipients of information. Gitt's (:47) conclusion is that 'information, being a fundamental entity, cannot be a property of matter, and its origin cannot be explained in terms of material processes'. This leads to the first of the 24 theorems of information:

> Theorem 1: The fundamental quantity information is a non-material (mental) entity. It is not a property of matter, so that purely material processes are fundamentally precluded as sources of information.

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[7] Subsection 2.1.1 contains Shannon's full definition of information.

This then naturally leads to us to ask: 'What then is the cause or the source of information?' Gitt's (1997:47) answer is that our volition, our will, is the cause of information and hence he introduces what he calls a 'fourth fundamental entity, namely **Will** (volition), W.' Information is thus seen to be always dependent on the existence of a sender who issued information according to his/her will (Gitt 1997:48). This leads Gitt (:48) to formulate the next theorem:

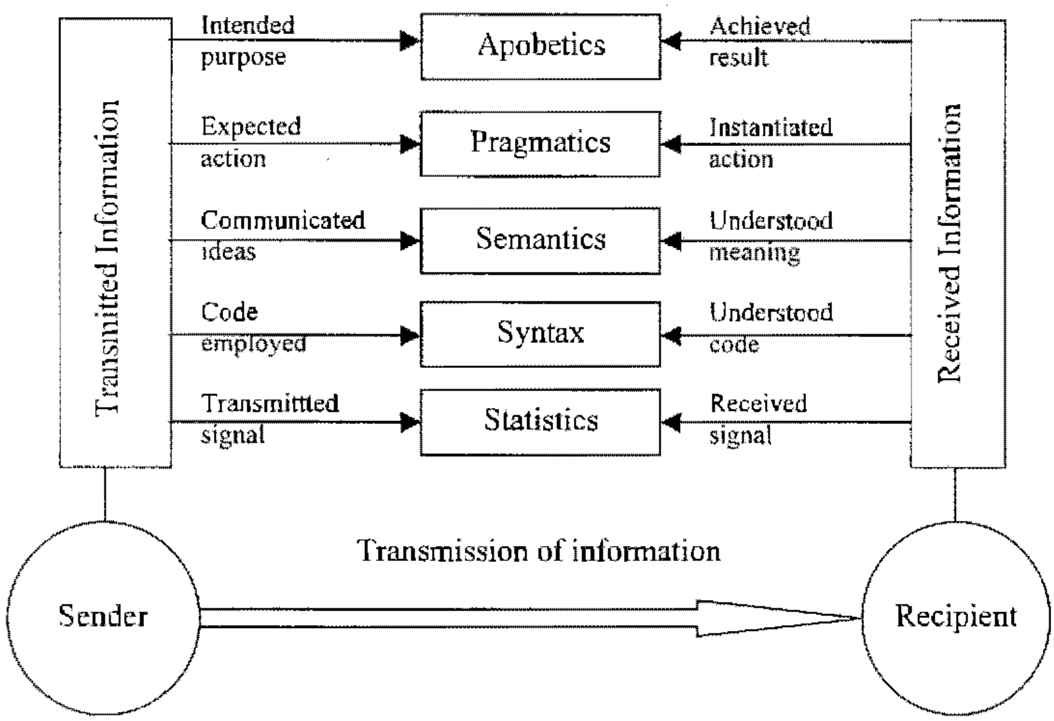
> Theorem 2: Information only arises through an intentional, volitional act.

He (1997:49) describes the following generic process for how the non-material entity, intentional information, can control matter: First, there is an intention to solve a problem, then a 'conceptual construct for which the information may be coded in the form of a program, a technical drawing', and, finally, the concept is implemented. An agent with volition is obviously present throughout as well. Thus **all** constructed objects have been produced via pre-existing information, and none were created 'through some form of self-organisation of matter' (:49). Gitt(:49) then draws the conclusion that 'information was present at the beginning, as the title of this book states'. This position is then summarised in the next theorem:

> Theorem 3: Information comprises the nonmaterial foundation for all technological systems and for all works of art.

Gitt has now dealt with one aspect of design, namely, man-made systems, or design as in that practised by engineers and artists. The further challenge is to move to biological systems and in order to do so he wants to 'formulate the theorems in such a way that they are valid as laws of nature, then they would be universally valid according to the essential characteristics of the laws of nature, N2, N3 and N4' (Gitt: 1997:49). N2, N3 and N4 basically entail that the laws of nature apply to everything, animate and inanimate matter, and to all fields of study.

Having sketched the outlines of Gitt's argument, we can now move on to summarise the full reach of Gitt's 'architecture' of all the aspects of information, as depicted in the diagram below (Gitt 1997:56):



There are five aspects of information and the role of the sender and the recipient must be factored in. It must also be borne in mind that, the 'information concept also includes the expected/implemeuted action (pragmatics), and the intended/achieved purpose (apobetics)' Gitt (1997:56).

Since we have already discussed the first level or aspect, namely the statistical aspect, we give a brief overview of the other four levels.

4.2.4.2 Syntax

Syntax includes 'all structural properties of the process of setting up information' which involves 'the actual sets of symbols (codes) and the rules governing the way they are assembled into sequences (grammar and vocabulary), independent of any meaning they may or may not have' (Gitt 1997:58). This level has two parts, namely the **code** (the set or system of symbols selected), and the **syntax proper,** which describes the inter-relationships among the symbols (:58).

In line with his general approach, Gitt (1997:63) makes a clear distinction between what he considers prerequisites for identifying a code system:

- A set of symbols is a code if:
    - 'it can be decoded successfully and meaningfully' (the one and only sufficient condition)

- It is not a code if:
    - 'it can be explained fully on the level of physics and chemistry, i.e. when its origin is exclusively of a material nature', or
    - 'it is known to be a random sequence (e.g. when its origin is known or communicated). This conclusion also holds when the sequence randomly contains valid symbols from any other code.'

As an example of a code that has a purely material nature, Gitt (1997:63) mentions the periodic radio signals received that were later identified as originating from pulsars (rapidly rotating stars).

As an aside here we can note that it is in practice very difficult to determine whether or not a sequence is random. Chaitin has shown that it is in fact theoretically impossible to determine whether a sequence is random, because there is no algorithm that can do this (Gitt 1997:126).

To Gitt (1997:64) a code 'always represents a mental concept, and, according to our experience, its assigned meaning always depends on some convention. It is thus possible to determine at the code level already whether any Diven [sic] system originated from a creative mental concept or not.'

The third level of information is semantics.

4.2.4.3 Semantics

Gitt (1997:69) gives the following translation of the Greek term *semantikós*: 'characteristic, significance, aspect of meaning'. The essential characteristic of conveyed information for Gitt (:69) is: 'not the selected code, ... but it is the message being conveyed, the conclusions and the meanings (semantics).'

As soon as we talk about meaning, a sender and a recipient are involved (Gitt 1997:70). Meaning is the only invariant property of information and hence it is essential to information (:70). Gitt (:70) sees meaning as always representing mental concepts and therefore his 15th theorem reads:

> When its progress along the chain of transmission events is traced backwards, every piece of information leads to a mental source, the mind of the sender.

Gitt (1997:71) also brings in the issue of language at this point:

> All suitable ways of expressing meanings (mental substrates, thoughts, or nonmaterial contents of consciousness), are called languages. Information can be transmitted or stored in material media only when a language is available.

The different kinds of language are: natural languages used by people for communication, artificial communication languages and languages used for signalling (Esperanto, traffic signs), formal artificial languages (logic, mathematics, computer programming languages), special technical languages (building plans) and the special languages found in living organisms (genetic languages, bee gyrations, instincts...) (Gitt1997:72).

According to Gitt (1997:72-73), language involves two processes: the sender formulates and the recipient comprehends, and both are, in general, accepted to be intelligent beings, or, in the case of a communication system (e.g. bee gyrations), an intelligent being must have been involved in creating the system.

From meaning Gitt moves on to purpose, the fourth level of information.

4.2.4.4 Pragmatics

Gitt (1997:73) gives the following translation of the Greek term *pragmatike*: 'the art of doing the right thing; taking action.' Here we are dealing with the purpose the sender has in mind for the recipient with the transmitted information (:73). Language is used to get the recipient to take some action (:74).

Finally, there is the highest level, dealing with the purpose that the sender has in mind.

4.2.4.5 Apobetics

Gitt (1997:76) coined the term 'apobetics' in order to conform to the titles of the other levels. The term is based on the Greek term *apobeinon*, which Gitt translates as: 'result, success, conclusion.'

This deals with the teleological aspect of information, the sender's plan, the premeditated purpose behind the information (:76). According to Gitt (:78), the other four levels are 'only a means for attaining the purpose (apobetics).' Gitt (:78) does note that 'the teleological aspect may often overlap and coincide with the pragmatic aspect to a large extent, but it is theoretically always possible to distinguish the two.'

Gitt (:78) feels that 'evolutionary doctrine' is in conflict with this aspect of information since it 'deliberately denies any purposefulness that might be apparent.'

4.2.4.6 Summary of the information levels

It is important to note that Gitt (1997:79) claims that all of his theorems are 'based on empirical reality' and therefore, he argues, 'they may thus be regarded as natural laws, since they exhibit the characteristics of natural laws'. These characteristics were discussed under Subsection 4.2.3: *Gitt's description of the scientific approach*.

Gitt (1997:80) summarises what he deems to be the most important results as follows:

- There can be no information without a code.
- Any code is the result of a free and deliberate convention.

- There can be no information without a sender.
- Any given chain of information points to a mental source.
- There can be no information without volition (will).
- There can be no information unless all five hierarchical levels are involved: statistics, syntax, semantics, pragmatics and apobetics.
- Information cannot originate in statistical processes.

Another way of summarising the information theorems and the levels of information is according to Gitt's hierarchy of phenomena (1997:81) or levels of complexity:

- Life
  - Life theorems: Gitt (:81) quotes Louis Pasteur: 'Life can only come from life'.
  - Life is not just information, although information is required for life.
- Information
  - At the level at which Gitt's information laws operate, information is non-material.
  - Information is not matter, but it requires matter as a medium for storage, etc.
- Matter
  - This is the level at which all natural laws operate.

Gitt's (1997:81) critique of the evolutionary view is that it regards life and information as 'purely material phenomena.'

Gitt (1997:84) formulates two fundamental properties of information:

> Property 1: Information is not the thing itself, neither is it a condition, but it is an abstract representation of material realities or conceptual relationships, like problem formulations, ideas, programs or algorithms. The representation is in a suitable coding system and the realities could be objects, or physical, chemical or biological conditions. The reality being represented is usually not present at the time and place of the transfer of information, neither can it be observed or measured at that moment.

Property 2: Information always plays a substitutionary role. The encoding of reality is a mental process.

Just as with Theorems 1 to 3, an intelligent sender is required (Gitt 1997:84).

Gitt now moves on to use the theorems to discuss the issue of information in living organisms, as well as the theory of evolution.

4.2.5 Gitt on life and evolution

Not only is information essential to life, but, to Gitt (1997:88), information is the 'central characteristic' of all life and it regulates all of life's processes. Of the three fundamental concepts, namely matter, energy and information, it is information that distinguishes the living from the non-living.

Gitt (1997:88-93) demonstrates that information is essential to life by discussing the way that the basic constituents of life, proteins, are manufactured in living beings. Proteins are built up from 20 different amino acids. Each of the 50 000 proteins in humans consists of a specific sequence of these amino acids. This sequence must be encoded somehow using a coding system, and then decoded by the protein 'manufacturing plant' in the cell.

The nucleic acid, DNA (deoxyribonucleic acid), a double-stranded molecule forming a double helix, is the storage medium used by the coding system. DNA is built up out of nucleotides, which consist of a carbohydrate, deoxyribose, to which one of four bases are attached, namely adenine (A), guanine (G), cytidine (C) or thymine (T) (Behe 1998:265). The nucleotides can become joined to each other via phosphate and hydroxyl groups attached to deoxyribose and DNA molecules range in length from several thousands to a billion nucleotides (:266). The nucleotides can also form weaker bonds (hydrogen bonds) with each other: A can bond to T and G can bond to C. This is the basis for the formation of the two strands, each of which is complementary to each other (:266, 268). Each amino acid is uniquely identified by a group of three contiguous nucleotides. So we have a code based on an alphabet of four 'letters' (A, G, C, T) which are grouped in threes to form 'words', and each 'word' codes for a particular amino acid (Gitt 1997: 90).

In a cell, transcription and translation take place with the help of RNA (ribonucleic acid) (Behe 1998:269). An RNA copy of a section of DNA, made via the transcription process, is then used in the translation process to produce a protein (:269-270). DNA and RNA are very similar in structure, except that in RNA the carbohydrate is ribose and uracil (U) replaces thymine (:265).

As an example: the amino acid serine is coded by the sequence: AGC AGU UCA UCC UCG UCU

Gitt (1997:94-96) contends that this coding system for the 20 amino acids is optimal. He argues as follows:

There are two parameters involved: the number of different letters (4 for DNA) and the length of the word coding for a particular amino acid (3).

The table below shows the number of combinations that are possible, for example, with 2 different letters (n=2) and a word length of three (L=3), 2^3=8 possible combinations of 3-letter words can be made. With 4 different letters and a word length of 4, 2^4=256 possible combinations of 4-letter words can be made.

		Word Length (L)		
		L=2	L=3	L=4
No. of Different Letters (n)	n=2	4	8	16
	n=3	9	27	81
	n=4	16	64	256
	n=5	25	125	625
	n=6	36	216	1 296

Due to the fact that there are 20 amino acids, we can exclude all possibilities that result in fewer than 20 possible combinations.

Gitt (1997:94) mentions the following requirements for the design:

1. To minimise the storage space required in a cell, the number of letters used to code for an amino acid must be as small as possible.
2. The number of different letter types must be even due to the need for replication and transcription of DNA.
3. To make replication more robust, a measure of redundancy in the code would be required.
4. The higher the number of different letter types, 'the longer the alphabet' and the higher the complexity of all the mechanisms such as replication, so copying errors should increase.

To minimise the storage space, any option with too many possibilities can be excluded, for example (n=4, L=4, 256).

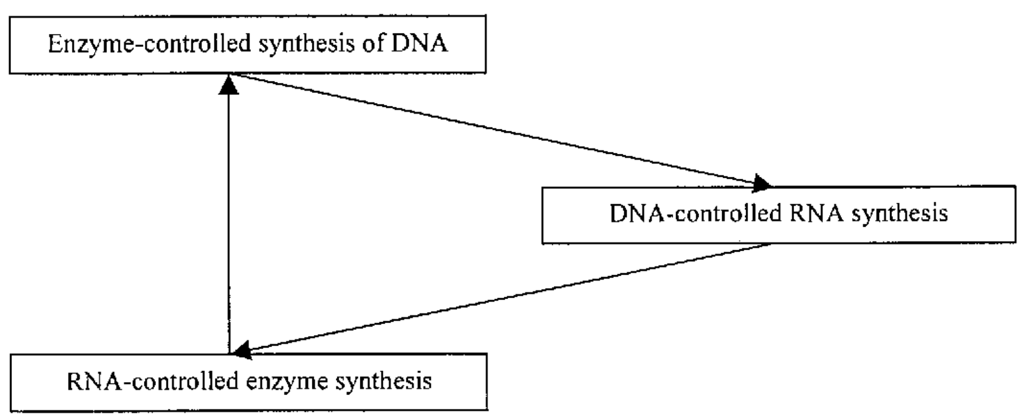
On the basis of the second requirement, namely that the number of letter types must be even, we can exclude n=3 and n=5; this leaves n=2, 4 or 6.

With the binary code, n=2, with large words, a word length of at least 5 (32 combinations) or 6 (64 combinations) is a possibility.

The quaternary code, n=4, with a word length of 3, provides 64 combinations. The word length of 3 results in fewer letters being needed to code for an amino acid compared with the binary word length of 5. The complexity is higher since there are now 4 different letters, vs 2 for binary, but the redundancy is also higher (64 combinations vs 32 for n=2, L=5). The end-result is that quaternary is more suitable than binary.

The other possible candidate is n=6, L=2 with 36 possibilities (with L=3 there are 216 possibilities which is far too many). Compared with the quaternary option, the complexity is higher (6 vs 4 letter types) and the redundancy is lower, (36 vs 64) and therefore the quaternary option, n=4 with L=4, is the optimum choice.

Gitt (1997:95) draws the conclusion that the fact that the coding system used for living beings is optimal 'strengthens the argument that it was a case of purposeful design rather than fortuitous chance'. Furthermore, since information is present, and it is not a different kind of information (see Theorem 25). Gitt (:97) simply applies his Theorems 1 and 2 to come to the conclusion that an intelligent source of the information is required (Theorem 26), and any theories that do not include such a source are false (Theorem 27). He (:98) also adds the argument that a 'cyclic information-controlled process' occurs in living cells, namely:



This leads to the question of how such a process could have originated – surely it must have been complete from the very beginning?

Finally, Gitt advances arguments against specific aspects of evolutionary views.

4.2.6 The core of Gitt's argument against evolutionists

The core of Gitt's argument, as is abundantly clear from the foregoing theorems, is that life started with information and one must be able to explain the origin of the information. According to Gitt (1997:99), 'All evolutionary views are fundamentally unable to answer this question'.

Gitt attacks several scientists for not fundamentally answering this question. He (1997:100) summarily dismisses the self-organisation argument as presented by Manfred Eigen, since it 'does not rise above the level of statistical information' and since Eigen offers 'Information arises from non-information', which to Gitt, is 'but a confession of materialism, and it fails the tests required by reality'.

Having 'established' his laws and levels, Gitt simply measures an argument against his yardstick.

Gitt also attacks scientists for simply assuming that evolution is true and then interpreting all of nature accordingly. His (1997:101) argument is that this point of departure is not based on sufficient fact. Rather, a point of departure is assumed and then 'all phenomena of nature is placed under the all-encompassing evolutionary umbrella'. This is 'pre-programmed folly', a 'mental corset', and the scientists 'degrade themselves to mere vassals of a materialistic philosophy'. Furthermore, 'evolutionary theory bans any mention of a planning Spirit as a purposeful First Cause in natural systems, and endeavours to imprison all sciences in the straight-jacket called the "self-organisation" of matter' (:101). Gitt's (:110) reaction is aimed against Franz Wuketits, who he claims supports evolutionary theory with 'near ideological fervour, and accuses everybody of fable mongering, who claims to be scientific and speak of ... a "designer" in nature'.

Gitt (1997:101) quotes Karl Popper, the noted philosopher of science, with approval since Popper, a supporter of evolution, once characterised the doctrine of evolution as a "metaphysical research programme". This classification removes, for Gitt (:101), the usefulness of evolutionary theory as a 'viable scientific *leitmotiv*'.

Apart from self-organisation, Gitt (1997:102-104) also discusses other relevant models for the origin of information in matter, namely cumulative selection, genetic algorithms and evolutionary models for the origin of the genetic code.

4.2.6.1 Cumulative selection

Gitt's (1997:102) argument against cumulative selection is directly mainly at Richard Dawkins and his 'computer monkeys' who arrive at a pre-determined phrase via mutation and selection mechanisms. Gitt (:102) makes the point that a goal-directed software program was used to achieve this, and that no information has been generated because, since the goal, the information-laden phrase, was pre-programmed, the computer always selected the phrase closest to the target phrase.

Gitt (1997:102) uses his Theorem 27 to refute this: 'random processes cannot give rise to information'. In my opinion this is an oversimplification since, just as Dawkins 'cheated' by using a goal-directed program, Gitt oversimplifies by not taking into account the random process **and** its interaction with its environment. The selection pressure caused by the environment may not be as goal-directed as Dawkins' software, but it does contain a measure of structure or order as a result of the action of the laws of nature. Ayala (1998:105) sees natural selection as a non-random process that selects combinations that are useful to the organism and hence the typewriter analogy needs to be refined as follows:

- We postulate that there are at least three kinds of typewriter.
- The first typewriter selects meaningful words every time they appear as a result of random typing.
- The second typewriter uses words rather than letters and meaningful sentences are selected when they occur.
- The third typewriter uses the sentences delivered by the second typewriter as its keys and selects meaningful paragraphs when they occur.

In this fashion a book could ultimately be produced that had 'meaning'. We could not treat this book in the same way as one produced by an author with a definite goal in mind, but it would have been selected to be useful, meaningful, in its environment, without there ever being something such as a predetermined goal.

In general, we can say that it is possible that interplay between the random process and the 'structured' environment could give rise to order and information[8].

Gitt (1997:127) denies that mutations can produce new information. His argument is that mutations only alter existing information, there is no increase in information and new creative information cannot arise; for example, new organs cannot arise. This is the old argument against the creation of complex organs such as the eye from light-sensitive cells via a chain of mutation and selection. Randomness, as evidenced in the form of mutations, cannot produce new information. The argument against this position as given in the previous paragraph is pertinent here as well.

4.2.6.2 Genetic algorithms[9]

Gitt (1997:104) uses the famous travelling salesman problem (What is the shortest overall route if you have to visit several cities?) to illustrate the principles of genetic algorithms: Using predetermined samples of bits (sequences of noughts and ones), each position is regarded as a gene. The sample is then modified (mutated) by allowing various genetic operators to influence the bit string (e.g. cross-over). A 'fitness function', assumed for the process of evolution is then applied to each result.

Gitt (1997:104) dismisses genetic algorithms as 'purely a numerical calculation method, and definitely not an algorithm which describes real processes in cells', and is of the opinion that 'Numerical methods cannot describe the origin of information.'

This is again a somewhat cursory dismissal. The fitness function, as in 'What is the shortest route?', does serve to guide the process, to select the best, but it does not fulfil the same role as the target phrase in the cumulative selection example. The target, the shortest route, is NOT known in this case. To my mind, information has been produced, i.e. the shortest route has been selected via random mutation and selection.

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[8] See also the discussion of Davies' work in Subsection 4.3.6: *From the first living thing to microbes.*

[9] Genetic algorithms are also discussed in Subsection 5.2.2.4: *Intentional causes and information as carrier of meaning* and in 5.6.7.8: *Computational neuroscience.*

4.2.6.3 Evolutionary models

In general, Gitt (1997:104) dismisses all evolutionary models for the origin of the genetic code as 'imaginary' due to lack of support via empirical evidence. In any case, Gitt's eleventh theorem 'lays down the law' that information cannot arise in matter!

Gitt (1997:105) quotes the attack by Fred Hoyle on the primeval soup theory of the origin of life (Hoyle's own 'panspermia' (life seeded via comets ...) theory is hotly debated):

> I don't know how long it is going to be before astronomers generally recognise that the combinatorial arrangement of not even one among the many thousands of biopolymers on which life depends could have been arrived at by natural processes here on the Earth. Astronomers will have a little difficulty at understanding this because they will be assured by biologists that it is not so, the biologists having been assured in their turn by others that it is not so. The 'others' are a group of persons who believe, quite openly, in mathematical miracles. They advocate the belief that tucked away in nature, outside of normal physics, there is a law which performs miracles.

The incredible odds against random arrangements of molecules creating the complex biopolymers such as DNA, is well known[10]. Hoyle's argument does not support Gitt's information-based argument directly. Gitt brings in Hoyle purely to show that other scientists also disagree that evolution and chance can explain the origin of life.

Another version of the argument regarding the interdependency of living systems is used by Lwoff, who states that:

> An organism is a system of interdependent structures and functions. It consists of cells and the cells are made of molecules who have to cooperate smoothly. Every molecule must know what the others are doing. It must be able to receive messages and act on them.

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[10] Davies mentions odds of $10^{40\,000}$ to 1 for a fairly simple system of proteins in Subsection 4.3.4: *From chemicals and energy to self-organisation.*

(Gitt 1997:106).

Gitt (:106) phrases Lwoff's argument in information language, stating that a 'complex net of available information' is needed by living organisms.

Gitt's arguments against evolutionary theories can be summarised as follows:

- Where does biological information come from? There must be a sender ... matter alone cannot create information.
- Information needs a carrier. Where do the biological information carriers such as DNA come from? How can they originate by chance? The high odds make spontaneous genesis highly improbable. No experiment has been able to create the information carriers spontaneously.
- Even if DNA did originate by chance, life depends on complex and interdependent systems and DNA on its own would not result in life.

Or in the simplest form: Where there is a code, there must be a sender.

Gitt's book could have been called: *In the beginning there was a Sender*.

4.2.7 Gitt on information and the Bible

In Gitt's scheme, any information-transmission system that sends creative information (see Appendix B) was designed by intelligence, and such a system comprises the following (Gitt 1997:115):

A Sender (the source of information)

↓

Information storage and/or Information transmission

↓

A Recipient (the receiver of information)

Gitt applies this scheme to the origin of life, the communication between God and humankind and the communication between humankind and God. Here we will only discuss the application of his scheme to the origin of life.

4.2.7.1 *The origin of life*

To Gitt (1997:137), the origin of the biological, operational information is the creative information from God. Science can only analyse the operational information and cannot find the Sender, which can only be revealed via the Bible. This view is expressed in a diagram (Gitt:137):

Sender	God the Creator (Source of creative information)	Genesis 1: 'and God said' appears ten times. Psalms 33:9: For he spoke, and it came to be; he commanded, and it stood firm. John 1:1: In the beginning was the Word, and the Word was with God, and the Word was God. John 1:3: Through him all things were made; without him nothing was made that has been made.

↓

The scientific boundary - science can investigate up to here[1]

Information storage and/or Information transmission

↓

Recipient	Living organisms		
	With the levels of information (operational information):	Syntax (Code, grammar)	Genetic code in DNA
		Semantics (Meaning)	Transcription of DNA
		Pragmatics (Action)	Translation of DNA leading to protein synthesis, and construction of the whole organism.
		Apobetics (Result, goal)	Existence of life

As we can see, science is being limited to the domain of the recipient. Finally, Gitt deals with Biblical analogies of the fundamental entities.

4.2.7.2 *Gitt's Biblical analogy of the fundamental entities*

Gitt's position is (Gitt 1997: 162):

- The four entities are: mass (or matter), energy, information and volition.
- Mass and energy are material.
- Information and volition are non-material.

- The material quantities are subject to conservation laws, but do not exist forever; they were created by God and have been performing their functions 'only since creation week' (Genesis 2:2, Jeremiah 10:12, Romans 1:20).
- Jesus was the active Person at creation, 'through Whom He made the universe' (Hebrews 1:2) and also the Sustainer, 'sustaining all things by his powerful word' (Hebrews 1:3). Also relevant are John 1:1-3 and Colossians 1:16. From all the above Gitt concludes the following:
    - 'Jesus is the Source of all energy,
    - Jesus is the Source of all matter, and
    - Jesus is the Source of all biological information.'
- Information was established in the beginning through volition (:163):
    - 'You created all things, and by your will they were created and have their being' (Revelation 4:11).
    - 'Christ, in Whom are hidden all the treasures of wisdom and knowledge' (Colossians 2:3).
- 'Everything that exists, does so through Christ; He is the First Cause of all things', a 'personal sustaining will' (:163).

For Gitt (1997:163), the four basic entities have a spiritual dimension in the Bible where humankind is concerned. For example, in Corinthians 2:14-15 'a distinction is made between the natural man and the spiritual man'.

A spiritual person lives in 'close communion with God (Ephesians 5:18-20), is 'in Christ' (John 15:4) and has access to the spiritual dimension of the Bible (:163-164).

In analogy to a spiritual person, Gitt (:164) talks about 'spiritual' matter, 'spiritual' energy, 'spiritual' information and 'spiritual' will. These entities 'originated' from God, the Creator.

Spiritual information is created by God by the sending of his Word, as per Isaiah 55:10-11, and he achieves his purpose (Gitt 1997:164). Spiritual information affects people by (:166):

- saving them from going astray

- preventing them from wasting their lives
- optimising their life situations
- saving their lives from damnation, giving them eternal life.

4.2.8 An appraisal of Gitt's approach

Gitt separates science and religion into two domains: science focuses on the HOW questions and religion on the WHY. Conflict arises when science oversteps its boundaries and tries to explain why, when first causes, the origin of things, is being discussed. In order to keep the delineation clear, Gitt uses explanatory schemes in which levels and hierarchies are defined. The top level, for instance the apobetic level of information, the issue of purpose, remains out of the reach of science. In Gitt's information-transmission scheme, the boundary of science is clearly indicated – science cannot discover the Sender (Gitt 1997:137). Gitt works with a particular model of information, which arose from a particular context, namely the communication model of communication theory. Although Shannon's mathematical communication model focuses on the communications channel only, the context is that of human communication and hence the issues of sender and receiver arise. This suits Gitt's purpose of convincing his reader that God is the Sender of information. Other contexts for information models are also possible, as Davies and Fisher have shown.

It is important for Gitt to emphasise the provisional nature of the findings of science. Various degrees of uncertainty and the issue of 'valid versus proven' are stressed. All this is used to undermine the strength of the claims made by people such as Dawkins by showing that they are operating outside the boundaries of science's domain and that their claims have no special status there since the claims are not empirically verifiable.

Gitt follows an aggressive approach, using the methods of science to refute scientists' claims. Science is not used against science itself, but Gitt sees two doctrines being pitted against one another: the doctrine of evolution versus the doctrine of creation. Gitt prefers to talk of the *doctrine* rather than the *theory* of evolution, which is normally the term preferred and used by creationists, since he wants to emphasise that, like Kuhn, we are dealing with a prevailing paradigm in scientific circles. Gitt does go further by attacking the scientific basis of evolutionary theory via his 'scientific' laws of information, a version of the design argument (the optimal coding scheme for amino acids carried by DNA) and complexity arguments.

To my mind the design argument does not fare well against evolution. Gitt is very selective in focusing on the optimal DNA design, without answering the obvious questions as to just how optimal are all of the designs we see around us. The designer can be accused of wastefulness and inefficiency if we look at all the species that have become extinct and the existence of vestigial organs that have no obvious purpose.

To a certain extent the argument is one of: What do you consider most likely or most believable – a Designer and Sustainer or blind chance? Gitt has to stress the improbability of spontaneous self-organisation and try to show that a Designer is a probable explanation.

Note the use of the phrase 'regarded as generally valid' with regard to the laws of nature (Gitt 1997:22). Does Gitt believe that general acceptance is based not only on 'scientific' reasons but also on social reasons?

The laws of nature occupy the top of his hierarchy of certainty in solitary splendour. They are elevated above paradigms. To Gitt, it is clear that paradigms cannot determine what he regards as the laws of nature. Yet it can be argued that this is exactly what Gitt does, by including Will in his theorems for example.

Note that Gitt subscribes to the model that the facts will speak for themselves. Does this not demonstrate that he is just as pre-programmed as the evolutionists are (Gitt 1997:101)?

Concerning the issue of design vs evolution, the question must be asked: Can evolution come up with an optimal design? Note that this argument is mostly used by creationists in the form of the complexity of a complete design (as per Gitt's argument about the RNA, DNA, protein synthesis cycle). Gitt also makes the simpler point that the coding scheme used for amino acid sequences is of optimal design. The point being made is that evolution may come up with a local optimum, but is it always simply the best?

Gitt states that information theorems cannot be used to refute the theistic view of evolution, the position that God initiated the process of evolution and guided it (Gitt 1997:136). Why not? Theistic evolution acknowledges the role of the intelligent Sender, but perhaps does not take the Bible literally enough for Gitt?

To Gitt, any argument that does not include a non-material source of information is simply not scientific. He (:136) quotes Dawkins' book, *The Blind Watchmaker*: 'The purpose of this book is to provide a non-supernatural explanation for the existence of complex organisms'. To Gitt (:136) then: 'we cannot expect to find a scientifically based answer in his discussion'. Gitt uses his edifice, or set of laws, which he says is based on empirical evidence and thus is scientific, to determine whether other approaches are scientific.

Gitt offers both of the types of explanation that Gregersen (2000:29-30) has elucidated. Gregersen (:29) discusses a higher-order metaphysical explanation of nature in general and scientific theories, so-called Explanation 1. Gregersen's paradigmatic example is the anthropic principle[11]. Gitt's main focus, however, is on a type of theological explanation that overrides scientific explanations, by calling in God to explain particular features of the world. Gregersen (:30) calls this 'the strong form' of Explanation 2. He believes that it is problematic since it casts God as the competitor rather than as the Creator of the laws of nature. Gitt denies that the laws of nature can produce information, since God is the source. Gregersen (:30) sees as more viable a so-called 'softer' version of explanation in which God is 'invoked to *complement* scientific laws' [Gregersen's italics]. Thus a theistic hypothesis may be used to explain why evolution leads to non-trivial outcomes (Gregersen 2000:30). Gitt dismisses evolution outright and cannot be 'accused' of supporting the weaker version of Explanation 2!

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[11] The anthropic principle refers to the links between the fact that life exists and many universal parameters having particular values. The various forms of the principle are discussed in Subsection 4.3.4: *From chemicals and energy to self-organisation.*

Gregersen (2000:29) does not believe that the role of theology is 'primarily that of *explaining* a world already explained by the sciences' and he warns against 'conflating the levels of a natural and theological explanation' [Gregersens' italics] (:30). Theology's role is to 'engage in a constructive re-description of a world already explained by the sciences' (: 31).

Ultimately, Gitt uses a form of the God-of-the-gaps argument in which God plays a direct causal role. This arises from particular points of departure about the nature of God, how the Bible must be interpreted and the relationship between science and theology.

From Gitt, we now move to a naturalistic view of life, evolution and information as propounded by a scientist, Paul Davies.

4.3 Paul Davies

4.3.1 Introduction

Paul Davies is a theoretical physicist, currently working at the University of Adelaide in Australia. He has written more than 20 books popularising science, including such bestsellers as *About Time, The Mind of God* and *God and the New Physics*. Davies won the 1995 Templeton Prize, from the Templeton Foundation, for his work on the philosophical meaning of science. In this study we will focus on Davies' recent book, *The fifth miracle: The search for the origin and meaning of life,* since it adopts an information-based approach to the problem of the origin of life. The title of the book refers to Genesis 1: 11 in which vegetation is mentioned as being the first form of life and, counting miracles from the start of Genesis 1, this seems to be the fifth miracle.

In the preface to his book, Davies spells out his reasons for writing the book and how his understanding of the problem of life grew. Originally he was convinced that science 'was close to wrapping up the mystery of life's origin', but his opinion changed and now he feels that 'there remains a huge gulf in our understanding' since 'we have a good idea of the where and the when of life's origin, but we are a very long way from comprehending the how' (Davies 2000:17). The gulf in our understanding is not merely just about some technical details, but it is 'a major conceptual lacuna' (:17). Davies makes it clear that he does not suggest that a supernatural explanation is needed, but he believes that we are 'missing something very fundamental' and that 'a fully satisfactory theory of the origin of life demands some radically new ideas' (:17). It is interesting that Davies feels that scientists are reluctant to admit in public to the remaining mystery of the origin of life, since they do not want to open the door to 'religious fundamentalists and their god-of-the-gaps pseudo-explanations' (:18). The perception of conflict between science and religion has had far-reaching consequences in restricting our options and hardening our positions.

Davies (:18) makes it clear that the mystery of the origin of life, or *biogenesis*, is on par with other deep problems such as the origin of the universe and the origin of consciousness, since it 'tests the very foundations of our science and our world-view'. In order to solve the biogenesis problem, Davies (:19) feels that we must first have a 'deep understanding of the nature of life'. Fundamentally, it is here that information comes into the picture. Davies' (:19) position is that although life is a chemical phenomenon, the 'secret of life comes instead from its informational properties; a living organism is a complex information-processing system'. Thermodynamics, especially entropy, provides the context for 'the ultimate problem of biogenesis: namely, where biological information came from', and, 'life was sparked not by a molecular maelstrom, but - somehow!- by the *organisation* of information' [Davies' italics] (:19). Note that Gitt asks the very same question as the core of his argument for the role of God as the Sender of information. Davies (:20) goes further to point out that if organisation of information is the key, then the 'crucial step involved the creation of an information-processing system, employing software control' and this is associated with the 'appearance of the genetic code.' To Davies (:20), the 'peculiarity of biological complexity' (vs other forms of complexity) makes genes seem almost impossible and he has come to the conclusion that:

> ... no familiar law of nature could produce such a structure from incoherent chemicals with the inevitability that some scientists assert. If life does form easily, and is common throughout the universe, then new physical principles must be at work ... Though I have no doubt that the origin of life was not in

fact a miracle, I do believe that we live in a bio-friendly universe of a stunningly ingenious character.

Note that Gitt would agree with Davies that the origin of life is not a miracle, in the sense that there was a Designer at work rather than 'a miracle'. Davies agrees that the end-result is 'stunningly ingenious' but does not infer or postulate a designer. Davies' solution to the problem is to postulate 'new physical principles', and in this he is in agreement with Gitt's overall approach of formulating information theorems or laws of nature. However, the contents of these principles differ radically from those of Gitt, as we shall see.

4.3.2 The origin of information and life

In his investigation of biogenesis, Davies covers a grand sweep from the birth of the universe to the appearance of conscious beings. He follows what he calls the top-down approach and the bottom-up approach. The top-down approach starts with the present living beings and tries to following the 'evolutionary path back in time and down in size' to ancient microbes (Davies 2000:81). The bottom-up approach starts with the environment of the newly formed Earth and tries to reconstruct the molecular events that led to the start of life (:81). In the diagram below the whole 'history' is summarised:

Humans
↑
Conscious beings — Top-down ↓
↑
The tree of life
↑
Microbes
↑
The first living entities (replication, etc.)
↑
Self-organisation — Bottom-up ↑
↑
Chemicals + energy
↑
Stars and planets
↑
Beginning of the universe

We will use this schema to explicate the role that information plays in biogenesis. Note that the top-down and the bottom-up arrows do not meet; this illustrates one of the gaps in our understanding.

4.3.3 From the beginning to stars and planets

Life needs energy and information. Where does biological information come from? Biological information is a special type of information, namely information with a context or meaning, i.e. semantic information (Davies 2000:60). To Davies (:60), the source of semantic information can only be the environment of the living organism, and then one has to ask: Where and how did the environment get this information? The ultimate environment is the universe, so we need to know the origin of the information content of the universe.

Here we come to the ultimate connection between energy, matter and information. The universe as a whole actually has zero energy. The sum total of the positive and negative energy at the Big Bang was zero. The positive energy became matter and the negative energy was stored in the gravitational field (Davies 2000: 61). The universe 'popped' into existence out of nothing, creating space and time, but required no energy input! If we say that information was present at the beginning, then we have to deal with the second law of thermodynamics, since the appearance of information is equivalent to an increase in order and thus a decrease in entropy. A decrease in the total entropy of the universe is against the second law of thermodynamics. Furthermore, studies of the cosmic heat radiation have shown that the fledgling universe was in a state of thermodynamic equilibrium, which is a maximum entropy state and hence contains the minimum of information. The early universe therefore contained very little information and the second law prohibits it from increasing. The way out of this dilemma is gravitation. Davies (:63) uses the example of a large gas cloud at uniform temperature which will remain in equilibrium unless it is large enough for gravitational forces to cause it to contract, ultimately forming stars. A star is a source of free energy or negative entropy. Gravitation leads to a decrease in the entropy of the system, so that the system can become more disordered than it already is. The conclusion is that a system will not be in true equilibrium, even if its temperature and density are uniform, if gravitation is present. The early universe, even if at uniform temperature and density, was therefore not in true equilibrium or the lowest state of entropy, and therefore *could* have contained information, as was clear later when galaxies formed which needed a huge amount of information to be described. As Davies (:64) puts it: 'a huge amount of information evidently lies secreted in the smooth gravitational field of a featureless, uniform gas ... this information flows from the gravitational field to the matter. Part of this information ultimately ends up in the genomes of biological organisms as biological information.'

Gravitational processes created a state low in entropy, which released energy as it moved to higher entropy states. This is the basic source of all free energy such as starlight and also the energy that all life thrives on. That is why Davies (2000:64) can say that 'the ultimate source of biological information and order is gravitation'.

However, this still does not explain the origin of semantic or meaningful information, or the origin of complexity. To Davies (2000:65), the complexity caused by gravitation is an example of how it is possible that a form of complexity, in this case gravitational complexity, can emerge from a simple state.

Since we are here considering the fundamentals of matter and energy, and the universe as the ultimate context for meaningful information and the ultimate environment for life, this is a suitable stage at which to formulate possible connections between matter, energy and information. Davies (2000:66) frames quantum mechanics in information terms. The description of the wave-like aspects of matter, the wave function, contains all that is known about a system; it represents the information content of the system. A key feature of the wave function is that it is spread out over space. Two particles that have been 'entangled', e.g. two photons created in the same event, remain coupled to each other even if they are at opposite ends of the universe. The wave function with its information load is therefore a truly global or non-local entity in contrast to a local quantities such as electric charge.

The theory of relativity forbids the transmission of information faster than the speed of light. that is particles can travel faster than light provided they do not carry information! All the cause-and-effect paradoxes that can be caused by faster-than-light information disappear if the information cannot be transmitted. A faster-than-light particle cannot carry information in itself –the context in which it constitutes a signal – so the information content is what causes the paradox. For example, a red particle means *stop* and a green particle means *go*. You can send the particle at hyperlight speed, but the signal ('red means stop, green means go') that will provide the context within which the detection of the particle has meaning has to travel at the speed of light. The particle that you see only becomes an information carrier if you know in what global context the particle was sent; the local measuring event is meaningless without the global context.

Davies (2000:67) concludes that 'both quantum mechanics and relativity suggest that information is a global rather than a local physical quantity.' To Davies (:67), this suggests that the origin of biological information will not be traced 'to the operation of local physical forces and laws' and if life is indeed written into the laws of physics, that is only true if the laws are not of the normal local sort. The origin of biological information must therefore be sought in some sort of global context which may be simply the environment in which biogenesis occurs. Or, as he (:67) speculates, 'it may involve some non-local type of physical law, as yet unrecognised by science, that explicitly entangles the dynamics of information with the dynamics of matter'.

4.3.4 From chemicals and energy to self-organisation

We are now closer to the crucial gap between the top-down and bottom-up approaches. The speculation about the bottom-up approach is informed by the debate on exactly what constitutes life. How do you decide what is living or non-living? As noted above, Davies works with a model in which the informational properties of life are paramount and thus the key step to life is the creation of an information-processing system that uses what he calls 'software control'.

As an aside, we could bring in here the anthropic principle and ask: Why does carbon, the versatile element on which life depends, exist at all? The answer could be that the laws of physics were fine-tuned to produce carbon. It could be said that the universe was designed via the laws of physics together with the precise values of physical constants needed to produce life[12].

The starting point is *organised complexity* since that seems to be the bare minimum for a first step on the road to life. The exact nature of such boot-strapped complexity also needs to be investigated.

One approach is to simply invoke 'chance' in the leap from molecules to complex life as we now know it. Davies has shown the tremendous odds against such an eventuality since there are simply not enough stars in the universe and there has not been enough time for even one simple molecule of life (e.g. a protein) to assemble spontaneously. We can arrive at amino acids in the laboratory via the famous 'primordial soup' experiments of Urey and Miller (Davies 2000:86), but a small protein (100 amino acids of 20 different varieties) has 10^{130} different arrangements of the amino acids, of which only a few will be biologically active, and this number is much larger than the number of atoms in the observable universe (Davies 2000:91, 278). If we consider that life as we see it now is based on hundreds of thousands of specialist proteins, then the odds of producing such a system of proteins (not even to

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[12] Barrow and Tipler wrote a book, *The Anthropic Cosmological Principle*, that contains a collection of evidence for the anthropic principle that the universe must have properties that make life possible. There are three distinct versions of the anthropic principle (Barrow & Tipler 1986:16-23): *The Weak Anthropic Principle* (WAP): The observed values of all physical and cosmological quantities are not equally probable but they take on values restricted by the requirement that there exist sites where carbon-based life can evolve and by the requirement that the Universe be old enough for it to have already done so.

The Strong Anthropic Principle (SAP): The Universe must have those properties which allow life to develop within it at some stage in its history.

The Final Anthropic Principle (FAP): Intelligent information-processing must come into existence in the Universe, and, once it comes into existence, it will never die out.

The weak anthropic principle has found a measure of acceptance, while the strong version, which they admit is speculative, has elicited controversy. The FAP, Barrow and Tipler's own creation, is even more speculative and has been called the completely ridiculous anthropic principle (CRAP) by Martin Gardner, the *Scientific American* columnist (Siegfried 2000:159).

mention DNA and RNA) are truly mind-boggling, $10^{40\,000}$ to 1 (Davies 2000:95). The implication is that we are truly and utterly alone in the universe, since life is extremely unlikely to have started twice.

It seems very likely that chance is not enough, we need chance + some unknown entity or law. So then we must return to boot-strapping ...

The end-result must be organised complexity and not just disorganised complexity as exhibited by many non-living systems such as coastlines, turbulent flow, etc. Examples of organised complexity are the galaxies and rainbows (Davies 2000:138). The next question is whether self-organised complexity is possible in non-living systems. The simplest example of self-organisation that is always mentioned is that of the formation of ordered hexagonal-shaped convection cells in a layer of liquid which is hot at the bottom and cold at the top[13] (:139).

The new science of complexity has made promising starts towards a theory of self-organisation via the chemical phenomenon of autocatalysis (Gregersen 2000:35-38, Davies 2000:139-142, Kauffman 1996). In catalysis, a catalyst is involved that participates in molecular reactions by reducing the energy barriers for the reacting molecules, while not being altered itself. When a catalyst molecule catalyses a reaction sequence that leads to the production of molecules identical to itself, this is termed autocatalysis. Thus a cyclical series of reactions is set up that forms a self-reinforcing web of reactions, a network (Davies 2000:140). When the diversity of the molecules in this network increases above a certain level, the network crosses a critical threshold. Kauffman predicts the abrupt formation of a huge autocatalytic cycle which is a simple form of metabolism, the organised chemical processes in living beings (:140). As Davies points out, the underlying principle seems universal. Computer models have shown that 'any network with enough components and interactions will tend to flip spontaneously into a state of organised complexity' and 'it may be that life is a consequence, not of special organic chemistry, but of universal mathematical rules that govern the behaviour of all complex systems, regardless of

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[13] This is called the Bénard phenomenon, and is also mentioned in the discussion in Subsection 5.6.4: *Active information.*

what they are made of' (:140). Kauffman (1996:48) goes as far as to say: 'The secret of life, the wellspring of reproduction, is not to be found in the beauty of the Watson-Crick pairing [RNA and DNA], but in the achievement of collective catalytic closure.' Here we have the basis of a bold claim that life emerged as whole life-systems, as geneless reactions, without a hierarchy of genes and proteins, and that life is thus simply a collective property of systems of interacting molecules (Gregersen 2000: 37).

Davies (2000:140-141) sees two major problems with the self-organisation theory spelled out here as an explanation of the origin of life:

- Convincing, 'real' experiments, i.e. not just computer simulations, are lacking.
- There is the deeper conceptual problem that life is an example of *specified* organisation rather than just self-organisation.

Specified refers to the fact that the genes of a living organism direct the organisation of the organism. In computer terminology, the DNA codes are read and the instructions contained in the codes are executed to build the organism. Davies (:141) calls this *internal* control. By contrast, the order of a convection cell is the result of *external* control by the boundary conditions, the environment.

Ian Stewart agrees with Davies that there is more than just self-organisation. To Stewart there are two secrets of life, namely:

- the mathematics of non-linear processes which form part of the laws driving matter towards increased complexity
- the highly specified information of the RNA-DNA-protein system (Gregersen 2000:36).

Davies (2000:141) concludes: 'The theory of self-organisation as yet gives no clue how the transition is to be made between spontaneous, or self-induced, organisation - which in even the most elaborate non-biological examples still involves relatively simple structures - and the highly complex, information-based, genetic organisation of living things ... we need to know how the very concept of software control was discovered by nature'. Kauffman would probably not agree with this statement.

Davies (2000:142) also points out that a fundamental distinction must be made between *order* and *organisation*. The concept of order refers to simple patterns such as are found in crystals for example, and ordered structures cannot store much information. Life is encoded via highly random structures that can store large amounts of information. Davies feels that the examples of self-organisation involve spontaneous ordering rather than the organised randomness that is required for life's density of information. Davies (:142) requires the existence of 'some new principle of self-organisation that induces the production of algorithmic complexity' to fill the gap of the biogenesis riddle.

In the end, Davies' verdict is that the bottom-up approaches are problematic, leaving the mystery of life unsolved.

So here we are at the end of the bottom-up approach (according to Davies) and the gap is still there – the leap of complexity ... the *lacunae* in our understanding.

4.3.5 From self-organisation to life (replication)

We now make the leap to living entities and the shift to the top-down approach. We have already mentioned some of the conclusions that Davies reached via his top-down approach to distilling the essence of life. Here we just give a brief overview since some of this material has already been covered by Gitt.

At this point we need to ask ourselves: Just what is life? How will we recognise it? What do we acknowledge as being living?

Davies (2000:33-36) lists the characteristics of life and the ones relevant to information are:

- Reproduction - replicating the means of replication as well (the genes)
- Metabolism and nutrition - a continuous flow of matter and energy, but energy alone is not enough, useful energy is needed.
- Organisation - organised complexity, co-operation between the components of an organism.

- Growth and development - replication combined with variation, leading to Darwinian evolution. If it evolves, it lives.
- Information content - The information needed to replicate an organism is carried by genes from parent to child. Information alone is not enough, however, it must have meaning to the system that receives it and it must have context, be specified. Davies (:35) asks: 'Where does this context come from, and how does a meaningful specification arise spontaneously in nature?'
- Hardware/software entanglement - nucleic acids store 'life's software' and proteins are 'the real workers and constitute the hardware' (:36). There is a communication channel between these two entities and a code, the genetic code. The channel and the code entangle 'the hardware and software aspects of life in a baffling and almost paradoxical manner' (:36).
- Permanence and change - the problem of being versus becoming. Genes replicate to conserve, but variation is needed in order to be able to adapt ... adapt or die ... Life exists precisely because of this creative tension between the two conflicting demands.

Davies (2000:36) summarises the crucial factors of life as metabolism and reproduction (replication).

For Davies (2000:36), it is appropriate that there is no simple defining quality for life, since science shows the natural world to be a unity and any clear separation between living and non-living could cause bias towards the belief that life is 'magical or mystical, rather than something entirely natural.' The reductionist approach simply does not work. There are no living molecules, only collective systems of processes involving molecules that are alive.

Whereas people such as Behe and Gitt flatly deny that science will ever explain the overall organisation of life, Davies (:99) believes that science will, 'eventually, give a convincing explanation for the origin of life, but only if the problem is tackled at two levels', namely:

- the molecular level (an insufficient explanation since the whole is more than the sum of the parts)

- the organisation level, the organism level, 'where co-operation is at a global level that cannot be captured in the study of the components alone'.

The basis of life is reproduction and reproduction is based on molecular replication. Here we again encounter the DNA story since the key molecular replicator is DNA. We are also moving from the molecular level to the organisation level.

Davies (2000:103-104) discusses the role of DNA as the carrier of genetic information. The four bases (A,G,C, T) can be described as a four-letter alphabet which can be used to spell out a message consisting of long strings of bases, which form what we call the genes. As Davies (:104) puts it: 'Viewed like this, life is just a string of four-letter words'!!

However, DNA cannot survive on its own. A whole organism is needed to replicate the genome, the full set of genes. This requires proteins, which are both the raw material of the organism as well as the enzymes that catalyse chemical reactions, thus providing energy to drive the metabolism of the cell.

The key issue is that DNA in fact stores the *instructions* to make the proteins. As mentioned before (see Section 4.2 on Gitt), messenger RNA reads the code that specifies the sequence of amino acids, the protein 'factories'. The ribosomes read the messenger RNA and construct the protein as an amino acid chain via the use of transfer RNA (each with an attached amino acid) which bonds to the messenger RNA.

Davies (2000:107) makes the point that 'the molecular traffic within the cell is essentially chaotic, driven by chemical attraction and repulsion and continually agitated by thermal energy. Yet out of this blind chaos order emerges spontaneously.'

So far we have discussed the molecular level only. In order to understand life, we have to move to the organisation level, start considering the organism's hierarchy of levels and start separating structure and function. Davies (:108) now makes the crucial point: 'The organisational power of living things requires co-operative processes that encompass many molecules and integrate their behaviour into a coherent unity'. The question now is: What can integrate the blind chaos of molecular activity?

To Davies, the real secret of life lies in the dual function of biological molecules. A gene is a biopolymer but it is also an instruction, the so-called genetic code. The genetic code is the code formed by triplets of bases for the different amino acids, as explained previously[14].

Here we have introduced the language of software. We now have two levels of description, two hierarchies, namely hardware and software, with the genes as the carrier of the software instructions.

The genetic code is truly universal and is found with very minor variations in all types of life. This fact leads to many questions and, as we have seen, the existence of this code has been used by Gitt to invoke divine design.

Davies (2000:110) agrees that the particular coding arrangement of three bases with four types of bases coding for 20 amino acids may be a good compromise between the benefits of having a large variety of amino acids versus reducing the translation risk. He does not ascribe the specific coding arrangement to divine design as Gitt does, but suggests that it evolved to satisfy chemical reasons at some early stage of life and became 'frozen in' as the only configuration. This does remain speculation, however. Davies views the origin of the specific coding assignments for the amino acids as a more difficult problem. Is it just an accident frozen in or are there good reasons why this code is optimal and why it evolved? The problem is: Just how can a code evolve if even one change in the code can destroy the system? As Davies (:111) says: 'To have accurate translation, the cell must first translate accurately'.

Speculative suggestions have been made that a rough code and an inaccurate translation process evolved together to form the complex system we have today. The system would have started off as very inefficient and tolerant of translation errors, gradually evolving into a more robust scheme.

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[14] Please refer to Section 4.2 on Gitt.

Davies (2000:112) reports speculation that there may be a deep connection between atomic physics and the genetic code. Peter Jarvis of the University of Tasmania has made claims that the genetic code 'conceals abstract sequences similar to the energy levels of atomic nuclei, and might even involve a subtle property of subatomic particles, called supersymmetry'.

Returning to the information perspective, Davies (2000:112-113) makes the following key point [my italics]:

> The conceptual point that goes right to the *heart* of the mystery of life is: *Any coded input is merely a jumble of useless data unless an interpreter or a key is available.* A coded message is only as good as the *context* in which it is put to use.

This goes back to the fundamentals of what distinguishes data from information – data becomes information only when a context is added. Only within the right context does something have meaning. By itself, genetic data are mere *syntax* and only become *semantic* data (data with meaning) because the system in a cell can interpret the information contained in the string of bases in DNA to form *specific* strings of amino acids (proteins) that are biologically active. As Davies (2000:112-113) points out:

> Genes and proteins require exceedingly high degrees of specificity in their structure ... Living organisms are mysterious not for their complexity *per se*, but for their tightly specified complexity. To comprehend fully how life arose from non-life, we need to know not only how biological information was concentrated, but also how biologically useful information came to be *specified*, given that the milieu from which the first organism emerged was presumably just a random mix of molecular building blocks.

So, basically, we need to be able to show how a random jumble of hardware can give rise to encoded software (:113, 115). Life is 'more than mere complexity, it is informed or instructed complexity' (:114). We are not talking about simply an increase in complexity or a 'husbanding of information', but a 'fundamental change of concept' moving to information-controlled systems, going 'digital' (:115).

In order to clarify the concepts of complexity and biological information, Davies draws on the theory of computation since he has shown the key role that information processing plays in life. Cells and computers have the same logical structure. For example, you can view DNA as the floppy disk with encoded information from which the instructions for the proteins of life are loaded.

The algorithmic or computer program definition of randomness (as developed by Chaitin), is very relevant to understanding the nature of DNA as an information carrier (2000:116-119). A random sequence is defined as a sequence that cannot be described by any shorter sequence of instructions as to how to produce it (an algorithm, for example '11111111111111111111' is not random because it can be replaced by 'print '1' 20 times'). The information contained in a random sequence of a particular length cannot be compressed or reduced any further, it contains the maximum amount of information possible in a sequence of symbols of that length). So, in order to contain the maximum amount of information, a DNA sequence should be nearly totally random. In fact this *is* mostly true of DNA. However, only a very small percentage of all the possible random sequences of DNA bases are biologically active (contain biologically relevant information), which is why we have stressed the highly specific nature of DNA's complexity. Genomes are highly random (in order to contain a large amount of information) and highly specific (in order for the information to be biologically relevant).

The idea of a law of nature can also be expressed in terms of algorithmic randomness as an algorithm that can be used to predict the behaviour of a system (Davies 2000:117-118). The data describing a system's behaviour can be compressed into an algorithm, the law of nature. As soon as patterns appear in the data, the data can be compressed by generating them via a series of instructions, the algorithm or law.

Davies (2000:120) asks the crucial question: 'How did a functional random and specific genome come to exist?'. Chance alone will produce randomness and law can produce 'a specific, predictable end-product', but how can chance and law 'co-operate to yield a *specific* random structure?' (:120). How can a highly specific type of information be produced by a non-living environment? Davies' answer is that no known law of physics and chemistry could yield specific randomness out of nothing, which he views as a fact of the deepest significance (see the next section for Davies' view on what can happen once a genome exists).

Davies (2000:121) feels that not only are we dealing here with technical issues, but also that at this point the fundamental changes in concepts lead us into the arena of philosophical problems too. It is dangerous simply to treat informational concepts in the same way as concepts coming from the natural scientist's description of the world. As Davies (:121-122) says: 'Unfortunately, "meaning" sounds perilously close to purpose, an utterly taboo subject in biology. So we are left with the contradiction that we need to apply concepts derived from purposeful human activities (communication, meaning, context, semantics) to biological processes that certainly appear purposeful, but are in fact not (or are not supposed to be)'.

So, whereas Gitt embraces these notions of purpose in order to involve God, Davies warns against confusion between the two worlds. This is due to the difference in their root assumptions as to the purposefulness of the world.

Davies (2000:122) does ask whether ultimately, since humans are products of nature, and if humans have purpose, we cannot argue that somehow this purposefulness must have originated out of nature, and hence must be intrinsic to nature. The question then becomes: At what level of nature is purpose present, right down to the molecular level? Again, an 'outside' source of purpose is not postulated.

For now, we can depict the gap between non-living and living as follows:

LIVING:	Hardware + Software	Information control	Specific randomness
	↑	↑	↑
NON-LIVING:	Hardware	Chance and chaos	Randomness

4.3.6 From the first living thing to microbes

We have now made the leap to the existence of some form of carrier of genetic codes, a genome. Two questions remain:

- What did the first genome look like?
- How did it increase in complexity to the level of microbes?

In the previous section, we mentioned the problems regarding a code evolving if a single change can destroy the very system by which it must be replicated. If there are no changes, then no adaptation can occur. A certain number of errors are therefore needed. Manfred Eigen coined the phrase the 'error catastrophe' for the critical error rate above which errors accumulate to the point that replication is affected and reproduction ceases (Davies 2000:57). The error rate will be optimal just below the error catastrophe if we assume that we want the maximum scope for adaptation. Davies (:59) quantifies this by examining the number of bits of information in an organism and seeing how many errors can be tolerated. Eigen has found that the more genes an organism has, the lower the error rate must be to avoid the error catastrophe (:59). Davies (:59) equates a hundred thousand genes (typical of higher organisms) to a hundred million bits of information stored. Human cells need to cut the error rate to about one in a 1 000 million by using complex error-correction mechanisms. Bacteria survive with an error rate of about one in a million.

This leads to a very important paradox. If we assume that the genomes of the first organisms were not supported by fancy error-correction mechanisms, then, if a genome is short enough to evade the error catastrophe, it may be actually be too short to contain enough information to be able to build the replication machinery (e.g. ribosomes). Eigen, for one, believes that this is indeed the case, that building the simplest replication machinery does, indeed, require more information than the error-catastrophe-limited genome can carry (:59). Davies (:60) calls this yet another instance of the chicken-and-egg paradox: Which came first, the genome or the replication machinery?

As Davies (2000:124) says: ' There seems to be an enigmatic circularity to life, a type of irreducible complexity that some people regard as utterly mysterious' (Michael

Behe for example). Davies (:124) makes the very important point that 'complex systems can get themselves irreversibly into cycles of dependence' so that although it is possible that the system could have evolved in many different ways from simple beginnings, 'once a cycle of dependence is established it rapidly becomes refined' and few traces of its simple origins survive. This is a very important issue in the overall debate between the designers and the evolutionists. The top-down approach, i.e. delving back to the possible origins of today's complex systems, is quite difficult. It is easier just to point out the complexity of the existing systems as the arguments for design normally do.

So, nobody expects DNA, proteins and their structures to have appeared out of the blue. One can postulate that simpler systems arose first and grew in complexity via feedback loops and Darwinian selection. Just what these simpler systems could be is highly uncertain. Davies (2000:125-137) mentions three possible scenarios, namely:

- RNA came first (then DNA) (the RNA world theory)
- Proteins came first and nucleic acids (RNA, DNA) later
- Clay crystals came first, acting as software, followed by organic molecules.

RNA can act as a weak catalyst and can catalyse its own replication, thus leading to a 'molecular evolution' scenario in which replication, variation and selection take place. According to some people's definition of life, this means that a self-replicating RNA molecule is a living entity (:128). This is in principle what could have happened. However, Davies (:128) points out that the experiments are specially designed, with custom-made replication enzymes for example, and thus do not reflect the natural conditions of a young Earth. Therefore truly spontaneous replication of even short lengths of nucleic acid bases in a primordial soup have not been demonstrated. RNA molecules are also fragile and need protection from attack by water. This, amongst other reasons, is why he (:131) concludes that 'without a trained organic chemist on hand to supervise, nature would be struggling to make RNA from a dilute soup under any plausible pre-biotic conditions'.

Even attempts to build smaller and simpler replicator molecules than RNA, although they have demonstrated some success in the laboratory, have failed to show that these replicators will form spontaneously in pre-biotic conditions (:133).

The other two theories are even more speculative. The *clay theory* is particularly interesting from an information point of view, since its point of departure is that nucleic acids function primarily as software and that therefore the specific chemical form, the specific nature of the information carrier, is irrelevant – all that matters is the ability to store information (Davies 2000:136). Clay can in fact store information in the different layers of the clay crystal, each layer with its own irregular arrangement of clay particles 'infused with metallic ions' (:136). Organic molecules could have become involved with the clay crystals to promote crystal growth in some fashion, and if some of these organics were self-replicating, then they could have taken over from the clay as the main replicator (:137).

The basic issue remains that somehow a simpler precursor to nucleic acid replicators must have started since the DNA-RNA-protein system is too complex. However, even a simpler precursor must be part of a fairly complex system, which brings Davies (2000:138) back to the issue of how the minimum complexity got started, and this is where the self-organisation debate kicks off. We have now again seen yet another gap, the gap between the basic replicators and the complexity of the replicating system of any sort of life.

Davies (2000:137-138) makes it clear that all the speculations about life's origin share the assumption that as soon as life of 'some sort had established itself, the rest was plain sailing, because Darwinian evolution could then take over'.

This then brings us to our second question: How did the first 'genome' increase in complexity?

4.3.7 Increasing the complexity of the genome via evolution

Davies (2000:120) casts the evolution of the genome in information terms. As soon as a genome and its support systems exist, Darwinian evolution, in the form of random mutations coupled with natural selection, can generate biological information by adding the bases to the random genome and thus adding information (:120). The randomness added by the mutations is sifted, selected out to be the specific, beneficent randomness of biologically active randomness or biologically meaningful information. The source of this information is the environment (the source of mutations and of selective pressure), but selection is the filter that turns it into meaningful information.

In terms of the theory of communication we can state that mutations on their own would be equivalent to simply adding noise to the messages in the communications channel and, in fact, the entropy will increase and the information content will decrease. When we add in the effect of the environment, which selects amongst the noise, this results in adding information to the genetic message (DNA) (:57).

This could be formulated in a different way. If we examine the basic definition of information as per the theory of communication, then information is just the exclusion (or non-selection) of possibilities and the more possibilities there are, the more information we have gained when we discover the actual state (Davies 2000:277). In effect, the action of natural selection is to let only certain genomes survive from amongst the huge range of genomes (organisms) that exist at that time. Since the other possible genomes have been excluded, since they cease to exist in future generations, information has been added to the surviving genomes (:277).

Gitt (1997:127) says that mutations can only cause 'changes in existing information'[15]. His basic argument against demonstrations of the effect of selection (as in the computer monkeys ending up with the pre-determined target sentence via mutation and selection mechanisms) is that the software program contained the information, the target sentence, and that therefore no new information was being generated. As we have seen above, new information does flow from the environment into the genome due to selection even though a pre-determined target does not exist! We can perhaps say that a 'fitness landscape', rather than a specific target genome, does in effect exist

[15] See also Subsection 4.2.6.1: *Cumulative selection* in the discussion of Gitt's work.

for the particular environment. Certain types of adaptations will survive in an certain environment, e.g. those with higher heat tolerance will survive in a desert.

We have now dealt with the two questions in very general terms. But in which entity did the first complex genome appear? The top-down approach can, in fact, only take us a limited distance back to the origins. We truly do not know what the first living thing was, but we do know that it seems that we had a universal ancestor and that there must have been a long evolutionary history between the first living thing and our universal ancestor (Davies 2000:78-79, 183).

We can, however, speculate on what the universal ancestor was. According to Davies (2000:183), the record of the genes suggests that the universal ancestor was living deep beneath the surface, at a high temperature (>100^{0}C), used sulphur as the energy source and was already sophisticated enough to have 'software-controlled' protein synthesis.

In broad terms, we can sketch how far we have progressed up to now:

Self-organisation -> low-tech precursor replicator -> first cell-like structure -> nucleic acid-based replicators -> microbe?

4.3.8 From microbes to us

The short answer to the question as to where human beings came from is commonly held to be evolution (as we have discussed in the previous section). The issue of how consciousness arose does, however, stand in the way of any 'easy' explanations (Davies 2000:184-186).

4.3.9 The riddle of biogenesis

As an aside Davies does raise the intriguing possibility that life never did start at all. Life may, in fact, always have existed. Fundamentally, there is no reason why it is not possible that the universe has always existed (Davies 2000: 248). Fred Hoyle has long been a proponent of this view. The most interesting implication of this theory is that if life has existed forever, then incredibly ancient and incredibly advanced life forms may exist that could have taken control over the entire universe, thus resulting in nature and technology being indistinguishable from each other, intelligence then being co-extensive with the universe (:249). This raises the interesting question of whether this is then indeed a possible concept of God — the classic pantheism view.

If we do assume that life did start somewhere, then we have to take a stand regarding the relative roles of chance and law. Due to the overwhelming odds against life arising as a result of pure chance, if that was indeed the case, it is extremely unlikely to have happened twice and therefore we would truly be alone in the universe. If life is discovered elsewhere in the universe which did not originate from Earth (or vice versa!), then the pure chance scenario will be ruled out.

The predominant view amongst scientists seems to be that we are not alone ... and therefore they do not accept that pure chance alone led to life. So, laws must necessarily have played a role. Life should be plentiful. If the laws of nature led to life on Earth, then they must lead to life on other, similar, planets as well. This view is called *biological determinism* or *predestination* (Davies 2000:252). It is quite illuminating that Davies (:252) feels that this view is 'widespread among astronomers, chemists, and physicists, but much rarer among biologists' who view chance as the major factor. This is in line with Davies' comments earlier in the book to the effect that that biologists are very averse to notions of purpose.

If one accepts that bio-friendly laws exist, then the next question is: What is the nature of these laws? Will the normal laws of physics suffice or do we need special laws?

Again, Davies' view is that 'few biologists today believe there are laws of life in quite the same way as there as laws of physics', the reason being that the idea of special laws to 'guide the development of matter towards life' is 'too mystical, too reminiscent of vitalism' (:252).

This then leaves the option that the laws of physics are all that is needed, for example the interatomic forces that result in the peptide bonds between amino acids may be able to discriminate between different sequences of amino acids, thus resulting in biologically active sequences being more likely to form out of the multitude of possible combinations. Some scientists have tried to defend this view, e.g. Sidney Fox who concluded that 'amino acids determine their own order in condensation', thus resulting in non-random macromolecules containing crucial biological information (Davies 2000:253).

Davies' position is that it would be really astounding if atomic processes had a built-in bias towards forming organisms since this would mean that a link exists between the basic atomic forces and the end -product, a complex organism. What is the nature of this link?

Davies' objection is that the laws of physics are simple (algorithmically simple) and general (2000:254). He therefore does not see how these laws, on their own, can lead to highly complex and highly specific entities. As we have seen, a highly random and specific sequence of nucleotide bases contains a great deal of biological information. However, no simple law can generate a highly random sequence – laws generate patterns, laws compress data or reduce information. As Davies (:254) says: 'Ordinary laws just transform input data into output data. They can shuffle information around but they can't create it'. Davies (:255) does not believe that life can be 'written into' the presently known laws of physics. To put the argument in another way, if the genome is both random and highly specific (information-rich), then it does not make sense to try to use non-random processes. Any combination of amino acid sequences must be possible in order to be 'chosen'.

Davies makes the point that life is not controlled by inherent tendencies, it is controlled by software that organises it to follow own reaction pathways. The secret of life lies not in the medium, but in the message, the 'logical and informational rules it exploits' (:256).

However, it is not possible to prove randomness, we cannot prove that there is some fantastically complex formula that generates the random sequence[16]. If this is true, then life may actually be simple, as, for example, fractals have demonstrated that complex-looking systems can be generated by a simple formula. Davies (2000:257) also makes the point that only the very first living thing would need to be generated in this way, since thereafter Darwinian evolution would add 'irreducible' complexity. Davies (:257) does not believe this, since it seems too 'contrived', a 'code within the code' is 'just too far-fetched'.

Even if we accept weaker forms of biological determinism, as in chance 'tempered by various physical constraints' that impose an overall directionality to life (Duve), or Kauffman's 'propensity for organised complexity to emerge under suitable conditions', Davies feels that the mystery of the origin of biological information remains (2000:258). How can random complexity and specificity be generated together in a law-like manner?

Davies (2000:258) sees two fields of inquiry that offer 'tantalising clues', namely the emergent laws of complexity and quantum mechanics.

The study of complex systems has revealed universal mathematical principles, 'laws' that derive from the logical structure of the system. A self-organising physical process may be able to bootstrap itself to a level of complexity at which the 'complexity laws' could kick in, leading to jumps in self-organisation and complexity that, 'ratchet the system up the complexity ladder', perhaps towards life (:259).

In contrast to the simple laws of physics, such laws might create new information, or 'at least wrest it from the environment and etch it onto a material structure' (:259).

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[16] Davies (2000:256) points out that this result is related to Gödel's incompleteness theorem in mathematics. Kurt Gödel proved that no system of mathematics that is as at least as complicated as ordinary arithmetic, could be both internally consistent and complete (Siegfried 2000:53). There are thus true statements in such as system that cannot be proven to be true.

Instead of regarding information as a derivative concept, this would mean regarding it as a physical quantity that can be traded by 'informational forces' in the same way that matter can be moved around by physical forces. Complexity must also be accepted as a physical variable with causal efficacy. Davies (2000:259) believes that software control, the genetic code, could only have arisen through the action of an 'informational law.' This view, that a law can create information, is also shared by people such as Manfred Eigen. Ultimately, Davies (:260) postulates that 'a blend of molecular Darwinism and laws of organisational complexity' offers an explanatory scenario, in which small replicator molecules form by chance, evolve further by Darwninian evolution, but at the same time, organisational principles are at work, which 'confer specificity and information' and 'amplify the selectivity of the evolutionary process'. Eigen talks of hypercycles amplifying the selectivity of the system (Davies 2000:290).

Davies' second line of inquiry is based on quantum mechanics, especially the issue of wave/particle duality (2000:260-262). When we describe an atom as a wave, we are really conveying information about a system. We are talking about the software. When we describe an atom as a particle, this corresponds to a hardware level of description. Davies (:261) describes a quantum measurement in information terms: During the measurement the wave changes suddenly, it 'collapses', and this is due to the fact that the knowledge of the system has changed. Since the particle's behaviour has also been altered, this is 'a sort of hardware-software entanglement', showing that information (knowledge) actually does have 'downward causative power' (:261). Davies (:261) now goes on to ask whether 'some sort of quantum-organising process be (is) just what is needed to explain the origin of informational macromolecules?'. After all, the forces acting to form the molecules bond-by-bond are quantum-mechanical.

Davies (2000:261) finds support in Schrödinger's idea of 'aperiodic' crystals being the unit of heredity due to the fact that they are stable enough to retain their form and complex enough to hold a lot of information. DNA is stable enough and has an aperiodic, mostly random, sequence of bases. Quasi-crystals are another type of aperiodic crystal, with five-fold symmetry. Five-fold symmetry does not allow a simple repetitive pattern. For example, to tile a wall, two differently shaped tiles with five-fold symmetry are required, the Penrose tiling pattern. The major implication is that, in order for a quasi-crystal to grow, some form of long-range organisation must be active, which might be quantum mechanical in nature.

Davies (2000:262) speculates that the study of the quasi-crystal, which stores an unlimited amount of information in 'its linear aperiodic sequence', may show how quantum mechanics can organise the formation of such complex structures which can store huge amounts of information. Davies (:262-263) thinks that 'a computationally impossible object', such as an algorithmically random genome, might be producible by quantum processes as hinted at by the study of quantum computation.

The idea that the laws of nature may be slanted towards life 'offends the spirit of Darwinism' and for many scientists biological determinism is 'tantamount to a miracle in nature's clothing' (:263). Davies (:263) recognises that the shift to a bio-friendly universe would be a major one away from the reductionist, materialist, meaningless universe. The issue of purpose is always present. Are we dealing with a random walk in evolution or a directed process toward intelligent beings? Should we equate direction with purpose or not necessarily? The general assumption is that evolution will not end up at the same point if the process is repeated from scratch. The only way to prove this would be to actually repeat the process of evolution or if we meet aliens that look like us!

4.3.10 An appraisal of Davies' approach

Gitt states that a code is a convention ... Davies asks: How did the code originate? Can the laws of nature produce codes? A law is a simple way to describe and predict complicated behaviour. Where do laws come from?

Davies does not duck the issue of purpose or try to simplify it as Dawkins does with statements to the effect that memes try to spread.

Davies' states that science rejects miracles (2000:81). We can ask who is doing the rejecting here, 'Science' or the people doing science? Davies' view of the scientific method comes out clearly here: 'Although biogenesis strikes many as virtually miraculous, the starting point of any scientific investigation must be the assumption that life emerged naturally, via a sequence of normal physical processes. In our present state of ignorance all we can hope for are a few pointers to the key chemical steps that may have been involved. We might be able to answer the question of just how likely or unlikely the spontaneous generation of life may be' (:81-82).

Davies' position relative to a spectrum of positions regarding acceptance of the notion of purpose, is:

Approach	Chance + simple laws (mutations + natural selection)	Chance + complex laws (laws of complexity)	Directed processes (A designer God)
Proponent	Most biologists, e.g. Monod	Some scientists **Davies**	Gitt, Dembski

To Davies, it is acceptable to introduce purpose if it is packaged into a law (a complex law, not a simple law). Gitt is much more explicit in making purpose/design into a law of nature.

Michael Behe has formulated the essence of the intelligent design argument in terms of information and his formulation makes the difference between his standpoint and that of Davies clear. The simplest possible design scenario is, according to Behe (1998:231), that there was single cell formed billions of years ago that 'already contained all information to produce descendant organisms.' This cell is the irreducibly complex system that was designed. We can test if the cell can contain enough DNA to code this mass of information. Behe (:231) holds out the option that the necessary information for designed systems could also have been added just before the system became operational, instead of lying unused, but ready, in the DNA. Unlike Gitt, Behe does not believe that all living things were created in just six days, but he does believe in a designer adding information at crucial points to systems over time. Davies postulates that complex laws may add the information from the inside as it were, that the laws plus the environment within which they act actually create information.

Behe (1999) has written a review of Davies' book in which he concludes that Davies' point of departure that specific design and a designer cannot be involved leads him into contradictions. Since Davies acknowledges that ordinary laws are 'information-poor' and that life is 'information-rich', he has to propose a new type of law, an information-generating law. However, one of the candidates for such a law, Kauffman's laws of complexity, dealing with self-organising systems, comes up against the problem that, as Davies points out, life is specified organisation, not just self-organised. Behe (1999:45) feels that Davies does not counter his own objections since he has to stay within his '(semi-) naturalistic framework'. Behe does not address Davies' attempts to speculate how such laws might create new information, or 'at least wrest it from the environment and etch it onto a material structure' (Davies 2000: 259). This is an area of research that will grow in importance and relevant results from research into artificial life[17] are discussed at a later stage in this dissertation.

We have mentioned that life is specified organisation. The person we discuss next, William Dembski, has investigated this property of life in detail.

4.4 William Dembski - Intelligent Design

4.4.1 Introduction

William A. Dembski, with PhDs in mathematics and philosophy and a Master's Degree in Theology from Princeton Theological Seminary, is one of the leading members of the Intelligent Design movement (Goode 1999). He is currently a senior fellow of the Discovery Institute Center for the Renewal of Science and Culture, a think tank located in Seattle. Other prominent members are UC Berkeley Law Professor Phillip Johnson and Lehigh University biochemist Michael Behe. Phillip Johnson, the author of *Darwin on trial*, is the *de facto* leader of the movement (Dembski 1999:20). Behe's 1996 book, *Darwin's black box*, which makes the case for the irreducible complexity of biochemical systems, is hugely influential and is used as an important resource for the intelligent design movement (Dembski 1999:20).

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[17] See Subsection:5.6.7.5: *Cellular automata.*

Goode (1999) traces the origins of the movement back to 1984 with the publication of chemist Charles Thaxton's book, *The Mystery of Life's Origin*, a book on chemical evolution which was co-authored with two other scientists. The book highlighted flaws in Darwinism and proposed the case for intelligent design in nature. The movement became more visible around 1992 and the first Intelligent Design conference was held at Biola University, in La Mirada, California, in 1996. Dembski edited the anthology, *Mere Creation*, that was produced after the conference[18]. Many conferences on this topic have been held since. A seminar on "Detecting Design in Nature" was held at the annual gathering of the American Scientific Affiliation in July 1999. A recent large conference was an invitation-only Intelligent Design Conference for intelligent design scholars, entitled: "A New Science for a New Millennium" held at Biola University from 2 to 5 December 1999.

The Intelligent Design Movement has its own professional journal, *Origins & Design*, and a quarterly magazine, *Cosmic Pursuit*, which is aimed at the general public. As mentioned above, a think tank has also been created, the Center for the Renewal of Science and Culture at the Discovery Institute (Goode 1999).

Robert Pennock, a Philosophy Professor at the University of Texas at Austin, attributes the interest the Design movement has attracted to the fact that: 'Unlike their earlier counterparts [known as Creationists], Intelligent Design scholars carry advanced degrees from major institutions, often hold positions in higher education, and are typically more knowledgeable, more articulate, and far more savvy.'[19] Due to the prominence of the movement, considered responses have been made, of which Pennock's book, the *Tower of Babel*, published in 1999 by MIT Press, is an example[20].

Dembski (1999:13) has given a concise definition of what intelligent design is:

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[18] From the website of the Intelligent Design Conference of 1999, called "After Materialism" (Available from URL: http://www.biola.edu/academics/torrey/calendar/design.cfm, [Accessed 26 November 2001])

[19] As quoted on the website referred to in the previous footnote.

[20] Pennock's book is discussed in Subsection 4.4.9.2: *The critique of naturalism*.

- a scientific research program that investigates the effects of intelligent causes
- an intellectual movement that challenges Darwinism and its naturalistic legacy
- a way of understanding divine action.

Intelligent design therefore operates at the intersection between science and theology (:13).

Dembski (1999:13) acknowledges that 'many scientists remain sceptical about its merits', since they think it 'makes for bad science (that it's just creationism in disguise), whereas many theologians think it makes for bad theology (that it misunderstands divine action).'

The main lines of argument of the intelligent design movement have been around the issues of: Where did the information contained in DNA come from? and How did the 'irreducibly' complex biochemical structures inside the cell come to be? Dembski has made important contributions to the fundamental information-based argument for design. His book, *The Design Inference*, explicated his argument that we can recognise design in specified complexity in mathematical terms, and *Intelligent Design*, published in 1999, presents the argument to the general reader. Behe has called Dembski's arguments the theoretical foundation on which judgments about design and contingency will be based in the future (Dembski 1999:12). The movement has always been concerned to be very scientific and Dembski's arguments have been seen as being able to provide a firm scientific foundation. The dust jacket of *Intelligent Design* quotes Rob Koons, who goes as far as to call Dembski the 'Isaac Newton of information theory'. In the discussion that follows, we will be focusing on this argument as presented in *Intelligent Design*.

4.4.2 Dembski's Intelligent Design argument

Dembski's goal is ambitious. He wants to 'show how detecting design within the universe, and especially against the backdrop of biology and biochemistry, unseats naturalism' (Dembski 1999:14). He foresees that Enlightenment rationalism and scientific naturalism are 'on the way out because they 'lack resources for making sense of an information age whose primary entity is information and whose only coherent account of information is design' (:14-15).

Dembski views intelligent design as 'a two-pronged approach to eliminating naturalism' (1999:120). The two prongs are a 'scientific and philosophical critique of naturalism' and a 'positive scientific research program' (:120).

4.4.2.1 The critique of naturalism

Dembski's motivation to attack naturalism is based on his conviction that 'for those who cannot discern God's action in the world, the world is a self-contained, self-sufficient, self-explanatory, self-ordering system' and as a consequence people will see themselves as being autonomous and the 'world as independent of God' (1999:99). The world is thus severed from God, which Dembski views as the 'essence of humanity's fall' from grace, replacing worship of God with idolatry, namely the worship of nature, investing it with significance it does not have (:99, 101).

It is important for Dembski to show that naturalism is not just a scientific standpoint, it is a world-view. He says that 'although viewing the world as nature is typically seen as a scientific move, we need to realise that it is a profoundly religious move' (Dembski 1999:100). Either you believe that the order we see in the world was created or you believe that it is intrinsic to nature. He does not believe that science can demonstrate that order is intrinsic, since 'this is not a scientific question but a metaphysical, yes, even religious question' (:100)[21]. Dembski's sees 'scientific naturalism', as holding 'the pretense that science has established naturalism once and for all', while science 'provides no evidence for naturalism one way or another '(:101). *Scientific naturalism* is the location of 'the self-sufficiency of nature in the natural laws of science' (:103). Naturalism, as well as commitment to divine creation, is a 'deep philosophical and religious commitment' (:101). Naturalism in Western culture 'affirms not so much that God is dead so much as that God is absent' and therefore intellectual honesty demands that we study nature without invoking God (:103). The

[21] To my mind, Dembski ultimately does want to expand science to be able to answer this question.

premise that science must be limited strictly to the study of undirected natural processes is called *methodological naturalism* (:119).

In order to defeat naturalism, Dembski attacks the self-sufficiency of nature which is located in the natural laws of science (1999:103). Dembski is of the opinion that we must show that the world is not self-sufficient, that God created the world as well as the laws of nature and that God 'upholds the world moment by moment' (:104). Evidence of God's interaction with the world must be produced since, if God's interaction is hidden, God's existence can even be affirmed by scientific naturalists, but this God will be 'a superfluous rider on top of a self-contained account of the world (:104). Dembski is a theist, not a deist. It is not enough to argue on a philosophical level that the 'world and its laws are not self-explanatory and therefore point to a transcendent source' or to hold this position as a matter of faith. Dembski wants to 'assert that empirical evidence supports God's interaction with the world, rendering God's interaction empirically detectable' (:104). This is a job for science. Dembski wants to meet the naturalist on his home ground as it were, on the empirical playing field. However, the rules of the game of science must be redefined as well. Dembski wants to break out of the naturalist's prescription that science deals only with *natural causes* and wants to include the study of *intelligent causes* as well (:105). The argument is that if 'we permit science to investigate intelligent causes (as many special sciences already do, e.g. forensic science and artificial intelligence), then God's interaction with the world, insofar as it manifests the characteristic features of intelligent causation, becomes a legitimate domain for scientific investigation' (:105). Note that the search for legitimacy, specifically scientific legitimacy, becomes prominent here. The search for extra-terrestrial intelligence, cryptography and archaeology are also mentioned as studies of intelligent causes (:106).

Dembski wants to replace the current terminology of 'natural and supernatural' with 'natural versus intelligent' causes. The definition of *intelligent causes* is that 'meaningful arrangements' result like Scrabble pieces on a table forming words (1999:105). This begs the question as to how meaning arises – Why does one arrangement of the pieces constitute words with meaning whereas another arrangement is 'meaningless'. To ask whether an intelligent cause works within or outside nature is a separate question to Dembski (:105).

It is Dembski's contention that this distinction between intelligent and natural causes 'has underlain the design arguments of past centuries' (1999:105). What is interesting is that Dembski makes the point that the design argument has been re-awakened due to *scientists* 'beginning to realise that design can be rigorously formulated as a scientific theory' (:106). Design is back in the scientific mainstream due to the presence now of a method that can distinguish between intelligently caused objects and unintelligently caused objects (:106). Note that earlier Dembski was trying to make the case that the study of intelligent causes is part of science in any case. Intelligent design is regarded as a new scientific research programme.

It is important to note that intelligent design does not speculate about what the intelligence is, it simply detects the working of intelligence (1999:107). This is due to the fact that the underlying entity that is found when intelligent causes are detected is information (:106). Intelligent design is a theory for detecting information, and is not the study of intelligent causes, 'but of the informational pathways induced by intelligent causes' (:107).

The scientific nature of intelligent design stands or falls by the empirical detectability of intelligent causes which is 'a fully scientific theory' and thus makes it different from traditional natural theology (1999:107). Whereas natural theology 'reasons from the data of nature directly to the existence and attributes of God', intelligent design only 'infers an intelligence responsible' for the data of nature (:107). Therefore intelligent design is 'at once more modest and more powerful than natural theology' (:107). It is more powerful since it is based on empirical and scientific claims and is more modest since it does not infer details about God – which task is left to theology. Dembski claims that one of the strengths of intelligent design is that it distinguishes between design and purpose (:107).

4.4.2.2 Intelligent design is a research programme

The main issue here is that intelligent design still asks the normal How? question of science and tries to understand how a designed object was made by trying to reverse engineer[22] what the designer did (Dembski 1999:108-109). Intelligent design enriches and extends science by adding new tools such as a new set of questions - What is the purpose? Is it optimal?, etc., as well as adding to science's conceptual categories (e.g. by adding design) (:151).

It is also a research programme in the sense that it has a methodology for the detection of intelligent causes.

4.4.3 Intelligent design in the context of the creation-evolution debate

In the area of biology, Dembski sees intelligent design as 'a theory of biological origins and development' which claims that 'intelligent causes are necessary to explain the complex, information-rich structures of biology and that these causes are empirically detectable' (1999:106). Due to the modest claim that only the existence of an intelligent cause can be shown, intelligent design is compatible with everything: from God intervening at every point, to 'far-ranging evolution' with God 'seamlessly melding all organisms together in one great tree of life' (:109). Having said that, Dembski takes care not to support the theistic interpretation of evolution or 'fully gifted evolution' since he sees it as being the same as atheistic evolution (:110). Dembski does not believe that God hides his tracks[23]. On the issues of whether it is beyond our abilities to discern God's actions, or the aesthetic criterion that a worthy God would not do it that way, Dembski feels that, instead of speculating, it is better just to investigate the world (:111). The theism in theistic evolution is actually superfluous to Darwinism, whereas design theorists partly reject evolution since their view is that the neo-Darwinian synthesis of evolutionary theory has failed (:111-112).

Dembski's contention is that the creation-evolution debate is more than just a debate about our scientific facts, it is about 'competing world-views and incompatible metaphysical systems' (1999:114). The battle is against a 'naturalistic metaphysic that

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[22] The concept of reverse engineering is used to describe the process of trying to find out how something was designed and manufactured. This is usually done in order to be able to make copies of the relevant object.

[23] Just how well God's tracks should be hidden is a source of debate. Murray (1994:69-71) argues that God must limit general revelation in order to limit epistemic coercion.

shapes and controls what theories of biological origins are permitted on the playing field in advance of any discussion or weighing of evidence' (:114). Naturalists would obviously say the same, accusing creationists of trying to prove the Bible right.

What then is the solution? Dembski offers intelligent design as the sword that will cut this Gordian knot! He defines the substance of the creation-evolution debate as being about whether life shows the marks of undirected natural causes, or whether life shows the clear marks of a designer (Demsbki 1999:116). The key question is thus whether naturalistic evolution or intelligent design is correct. All other issues then become irrelevant and only empirical tests remain. Dembski rejects the position that intelligent design addresses a 'religious' question and that therefore his question is not legitimate (:117). The reason that intelligent design is regarded as a religious question is because 'the Darwinian establishment, by definition, excludes everything except the material and the natural', and hence 'all talk of purpose, design and intelligence' is ruled to be outside science (:117). Dembski's counter is that both intelligent design and naturalistic evolution 'inquire into definite matters of fact' (:118). So, Dembski asks us to 'dump methodological naturalism' and thus to let the two theories fight it out on the empirical battleground without any prior assumptions about what is scientific or not and without metaphysical naturalism (:119).

4.4.4 How do we detect design?

Dembski (1999:127) uses design in three different senses:

- 'to denote the scientific theory that distinguishes intelligent agency from natural causes' (design theory or intelligent design)
- 'to denote what it is about intelligently produced objects that enables us to tell that they are intelligently produced and not simply the result of natural causes' (finding the vestiges or footprints left by intelligence)
- 'to denote intelligent agency itself' (an intelligence caused it).

Dembski's measure is the complexity-specification criterion, which he has also called a 'specification/small probability' criterion in his book *The Design Inference* (1998b:127, 290). In order to infer design, three characteristics must be established (Dembski 1999:128):

- Contingency - the object is not the result of an automatic process

- Complexity - the object is too complex to be able to be explained by chance alone
- Specification - the object exhibits the type of pattern characteristic of intelligence.

An object is contingent if it can be established that it could be produced by natural processes which permit any number of alternatives, but it is not required that this particular option be realised, i.e. the object cannot be attributed to 'any underlying physical necessity' (:128-129). Dembski gives the example of Scrabble pieces on a game board that are 'irreducible' to the laws of motion (:129). In other words, if you throw Scrabble pieces at a game board, they might land in a particular configuration, but the laws of nature do not proscribe what configuration will occur.

Complexity is tied to probability. A complex arrangement of Scrabble pieces is unlikely to happen, it has a low probability of occurring. Complexity is inversely related to probability. However, as Dembski acknowledges, complexity alone is not enough (1999:130). The operation of chance alone can also generate complexity as in the particular sequence of heads and tails you establish when tossing a coin a 1 000 times (:130).

This is where the issue of specification comes to the fore. A certain *type* of pattern needs to be present in order to be able to infer design. Dembski has been criticised for calling design 'that which is left when chance and regularity have been eliminated' (Holder 2000:180). Hence the whole issue of what is meant by specification is very important.

Dembski (1999:132-133) divides patterns into two types, namely *specifications*, the non-ad hoc patterns that in the presence of complexity warrant a design inference, and *fabrications*, ad hoc patterns that despite the presence of complexity, do not warrant a design inference.

At this point three elements need to be distinguished which are essential for inferring design (:131):

- A reference class of possible events (flips of a coin for example)
- A pattern that restricts the reference class of events (7 tails followed by 3 heads, 3 tails, 3 heads?)
- The precise event that has occurred (the actual series of flips of the coin).

A design inference links the reference class to the event via the pattern (:131).

A pattern can be identified before an event, for example in designing experiments, or after the event, as in deciphering an unknown code (Dembski 1999:132). The important issue is that the pattern must be *independent* of the particular event it describes (:133). Dembski (:133) calls this relation of independence *detachability* and such patterns are said to be *detachable.* If we are given an event and a pattern describing it, then a detachable pattern is one that can still be constructed from the range of possible events without knowing which of these possible events actually happened (:133).

How do we construct this pattern? Dembski introduces the notion of the need to use additional side information in order to eliminate chance (:138). To illustrate this he (:135-138) uses the example of an event E, consisting of a sequence of 100 heads (H) and tails (T):

THTTTHHTHHTTTTTHTHTTHHHTTHTHHHTHHHTTTTTTT...

Statistical tests show that it is random: there are 50 alterations between heads and tails, there are 49 heads and 51 tails, there is a sequence of seven tails in a row, which can be expected statistically, etc. The sequence of heads and tails is now transformed into a sequence of 1's and 0's, called pattern D:

01000110110000010100111001011101110000000...

This pattern D is not detachable (yet!), it was simply read off from the particular event E. However, pattern D can be generated without referring to E at all, simply by rewriting D as:

0 (binary)	0 (in decimal)	
1	1	
00	0	
01	1	
10	2	
11 $(1 \times 2^1 + 1 \times 2^0)$	3 (3×10^0)	(Remember that $x^0 = 1$, therefore $2^0 = 1$ and $10^0 = 1$)
000	0	
001	1	
010	2	
011	3	
100	4	
101	5	
110	6	
111	7	
0000	0	

etc.

We recognise that this is a sequence generated by writing binary numbers in ascending order, moving from one-digit to two-digit to three-digit numbers, each time starting at 0. Hence E is a pseudo-random sequence and D is the non-random pattern describing it. The probability of sequence E occurring is 1 in 2^{100}. In order to eliminate chance, the additional side information that has to be used is the knowledge of binary arithmetic, which detaches the pattern D from the event E and thus makes D a specification (Demsbki 1999:138).

In order to avoid the contention that side information is ad hoc, Dembski (:138-139) places two conditions on side information, namely:

- conditional independence
- tractability ('do-ability').

Conditional independence, a concept from probability theory, is epistemic independence, i.e. knowledge of the side information must not affect the knowledge of the occurrence of event E. This means that the probability of an event must not change if we take the side information into account. In the example given, this is true since knowledge of the binary number system cannot affect the probability of a sequence of coin tosses.

The tractability condition requires that the side information enables the construction of the pattern D to which E conforms. The meaning of 'enables' is described by complexity theory, a generalisation of computational or algorithmic complexity theory, which 'assesses the difficulty of tasks given the resources available for accomplishing those tasks' (Dembski 1999:138, see also Davies 2000:116-120).

These two conditions are a means of ensuring that the pattern is constructed from an event without 'recourse to the actual event' (Dembski 1999:139). Specifications are then these non-ad hoc detachable patterns. Dembski uses these conditions, it seems, to guard against allegations that an event can be interpreted in an ad hoc fashion to suit one's purposes (as in attributing intelligent design!).

4.4.5 The complexity-specification criterion in action

The way to assess the reliability of a criterion is to investigate the proportion of false positives and false negatives in relation to the number of correct identifications.

In the case of the complexity-specification criterion, a false negative occurs when the criterion does not detect design in an object that was designed. Dembski (1999:140) says this difficulty is 'endemic to detecting intelligent causes' since 'intelligent causes can mimic necessity and chance, thereby rendering their actions indistinguishable from such unintelligent causes'. A young boy's room often testifies to this – it looks chaotic, but an intelligent cause was behind it all! An intelligent agent can also act intentionally to hide its actions (e.g. via encryption of data) or we might not know enough to enable to detect the design (the side information is lacking!). Dembski's contention is that false negatives do not invalidate the complexity-specification criterion since it will detect intelligent causes that do intend making their handiwork known (:141).

Bearing Dembski's intention in mind, it is clear that the issue of false positives is more important to him. One does not want to attribute design to something that was *not* designed. The criterion must reliably detect design even at the cost of actually rejecting some designed things, otherwise it is worthless (:141). Dembski (:142-146) advances two arguments for the reliability of the criterion with regard to false positives, namely an inductive argument and an argument about the special qualities intelligent agents have that make them detectable.

The inductive argument simply says that 'in every instance where the complexity-specification criterion attributes design and where the underlying causal story is known, it turns out design actually is present; therefore design actually is present whenever the complexity-specification criterion attributes design' (:142). Dembski dismisses the naturalist argument that extrapolation of design beyond the artefacts of human designers is not possible, since this is based on circular reasoning which already assumes that naturalism is true.

At this point Dembski addresses the issue of just how we can distinguish between chance coincidences and design? The filter that Dembski proposes is that the probability must be small enough, less than his so-called 'universal probability bound'[24] of 10^{-150} (1999:143). The issue of just how one determines the probability of an event is contentious, as we will discuss later. In any case, inductive arguments can never constitute absolute proof – there may just be black swans out there even if the probability is very small! (The full argument is: 'All the swans I've seen are white, therefore all swans are white'.).

Dembski's second argument about the special nature of intelligent agents revolves around the identification of the principal characteristic of intelligent agency as being the choosing between alternative possibilities[25] (:144). Dembski argues that the complexity-specification criterion fits in with our general scheme for recognising intelligent agency, namely that one out of several competing possibilities was actualised and the possibility actualised could be specified beforehand as being appropriate (:145). The example Dembski uses is a rat learning to navigate a maze (:145). The psychologist specifies beforehand which selection of right turns and left turns will get the rat out of the maze. If the rat has learned how to get out quickly, it will make this selection amongst all the possible choices of routes and this behaviour will be recognised as being intelligent instead of constituting just random wanderings.

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[24] $10^{-1} = 1/10$, or 0.1, so $10^{-150} = 1/10^{150}$ which is very close to 0! Dembski contends that anything that is less probable than this cannot be attributed to chance. The universal probability bound is proposed in Section 6.5 of his book, *The Design Inference* (Dembski 1998b).

[25] This can be linked to the mathematical definition of information as being related to the exclusion of possibilities: the more possibilities excluded, the higher the information content is.

The catch with this example is that a robot can also learn to navigate a maze and thus also be judged to be intelligent, since it possesses 'machine intelligence' as we normally call it. Dembski does add that the maze must be complex so that many possibilities exist and it will be unlikely that chance alone could result in the correct choice. This does not change the argument that machine or artificial intelligence will pass this test and that it is not necessarily an intelligent causal agent. Searle's "Chinese room" argument[26] is along the same lines as well. You can translate Chinese without knowing it, you can appear to be intelligent without being truly intelligent. This impinges on just what sort of intelligent agent it is that this complexity-specification criterion can detect.

To conclude the second argument: Dembski contends that this generic method for recognising intelligent agency contains all the elements (actualisation, selection, and specification) that are present in the complexity-specification criterion (:146). Hence the criterion merely formalises the normal method for recognising intelligent agency.

Dembski contends that his criterion 'detects design strictly from observational features of the world' and that it is based on probability and complexity theory and not on metaphysics and theology (1999:149). He admits that his criterion does not 'achieve logical demonstration', but states that it 'does achieve statistical justification so compelling as to demand assent' (:149). The compelling nature is the result of the

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[26] John Searle has developed the Chinese room argument which tries to show that people understand what they do whereas computers do not (Siegfried 2000:127-129). The thought experiment involves putting a person who does not know Chinese into an empty room that has only one channel to the outside world. The person has a stack of cards that contain Chinese symbols and a book of instructions in a language that the person can understand, e.g. English. The instructions (like a computer program) tell the person what symbols to send out in response to Chinese messages coming in via the channel. When the person receives a Chinese message, he or she consults the book of instructions and passes back a card with a Chinese symbol as the instructions dictated. To an outside observer, the person would appear to be responding appropriately to questions posed in Chinese symbols (provided the instructions were adequate) even though the person would have no idea of what had been communicated. To Searle, this illustrates the instruction-based input-output system of a computer and demonstrates that the computer does not understand what it does (:128). This example has been the subject of many debates and the issue of what is understanding has not been resolved. Cilliers (1998:48-57) provides a good overview. See also Subsection 5.6.7.8: *Computational neuroscience*.

sheer magnitude of the odds against chance and law (Dembski's 'universal probability bound' of 10^{-150}).

4.4.6 The connection with irreducible complexity

According to Dembski, Michael Behe's notion of irreducible complexity as explicated in his book *Darwin's Black Box,* satisfies his complexity-specification criterion (:149). Behe's biological systems are complex due to the interrelatedness of the parts of the system, which therefore have to be selected carefully, otherwise the system will not work (:147). Dembski states that 'in virtue of their function these systems embody patterns independent of the actual living systems' and therefore these systems are also specified (:149).

Dembski has also formulated intelligent design in terms of information and we will now discuss his view.

4.4.7 Intelligent design and information

Dembski (1999:156) uses the mathematical theory of information and follows Shannon by defining the measure of information in an event of probability p as $-\log_2 p$, which is always positive or zero[27]. This is a measure of complexity that is measured in bits, namely the number of bits needed to identify an event of probability p. In other words, the more members there are of the set of possible events, the larger the information complexity. This measure says nothing at all about the possibilities of patterns in the set of events.

If an event A has a probability of occurring given by P(A), then the amount of information in event A, I(A), is given by $I(A) = \log_2 P(A)$. I(A)is the measure of the number of bits associated with P(A). The probability of an event occurring can therefore be quantified in bits[28].

[27] Shannon's formula is discussed in Subsection 2.1.1: *Shannon's information theory.*

[28] The concept of a bit is also discussed in Subsection 2.1.1.

The conditional information of B, given A, is defined as I(B|A). It is the amount of information contained in event B once event A is taken into account. The conditional information contained in B, given A, is the unique information in B that is not in A. Hence I(B|A) = I(A&B) - I(A), where I(A&B) stands for the information that is in A and B and I(A) is the information in A.

The linkage with Dembski's previous definition of complexity is via the probability of an occurrence of an event. Previously Dembski (1999:129) used the example of Scrabble pieces: a complex arrangement of Scrabble pieces is unlikely to happen; it has a low probability of occurring and hence complexity is inversely related to probability.

Specifications are non-ad hoc detachable patterns of events and information is transmitted through events (:159). Events can be specified or unspecified and so information can also be specified or unspecified. Finally, we get to what Dembski calls *complex specified information* or CSI, information that is both complex (contains many bits) and specified (:159).

To Dembski CSI is the underlying information concept of many endeavours to understand nature's complexity, such as the fine-tuning of the universe, the movement of information (CSI) between the organism's environment and the genome, and the irreducible complexity of Behe's biochemical machines (1999:159). Particularly important in the context of complexity theories is the contention that it is CSI 'that within the Kolmogorov-Chaitin theory of algorithmic information identifies the highly compressible non-random strings of digits'[29] (:159). Random events are represented by non-compressible strings of bits, whereas non-random events (patterns) can be expressed by an algorithm (:292). The algorithmic complexity of CSI is therefore low due to the presence of pattern.

Information theory and design are connected simply via the fact that 'to infer design by means of the complexity-specification criterion is equivalent to detecting complex specified information' (:160). The elements of the criterion, the contingency,

[29] See also Subsection 2.1.3: *The different formulations of information*, and

complexity and the specification of an event, are mirrored in the CSI of an event. Contingency results from an event being one of a set of possible events, which is described by a probability, which in turn can be expressed as information.

4.4.8 Where does information come from?

Dembski asks the same question that Gitt and Davies ask. The naturalist position is that the combination of law and chance produces information. Dembski attacks law and chance on their own and then the combination of them acting together.

4.4.8.1 Laws and algorithms

Dembski advances a mathematical argument, using the concept of CSI, to show that algorithms and natural laws cannot originate information (1999:160-165). Mathematically, laws and algorithms are functions. Functions are relations between two sets. Functions map a member of a set (called the domain) to a unique member of another set (called the range). For example, the function f could map each element x in the domain to element (x^2) in the range. In the case of algorithms, the domain is the input data and the range is the output data. A natural law's domain is the initial conditions and boundary conditions, and the range is the physical states at subsequent times. We can say that a natural law maps initial conditions to later conditions.

Dembski (1999:161) now asks us to consider information j, which is CSI information, and a function f (law or algorithm) that led to the origin of the information j. Some element i, in the domain of f, was then mapped to j by f, in mathematical terminology $f(i)=j$. Dembski makes two points:

- Where does i come from? The problem of infinite regression looms, so ultimately there must be a source of information.
- The functional relationship between i and j will never add information, although it may keep intact what information is already there or degrade it. If i was complex specified information, then j must have been at least as complex and specified.

In terms of the conditional information theorems explained in the previous section, the last point can be formulated as follows (:161):

- $I(i\&j) = I(i) + I(j|i)$

The information that is in *i* and *j* is equal to the information in *i* added to the unique information in *j* that is not in *i*, the conditional information. Furthermore:

- $I(j|i) = 0$ There is no unique information in *j* that is not in *i;* it can be less or equal to that of *i*.
- Therefore $I(i\&j) = I(i)$ No information has been added.

The issue of whether the function itself can contain information is also addressed (:162). If we look at my simple example of $f(x) = x^2$, then x^2 will contain more bits and hence more information as per our definition of information. This information is already contained in the function and the amount of information has not been increased:

the information contained in function $f(x)$ + the domain, the set of x's

is equal to

the information contained in $f(x)$ + the range, the set of x^2's.

Dembski (1999:165) concludes that the basic issue is that laws and algorithms are 'deterministic and thus cannot yield contingency, without which there can be no information'. Information flows and degrades but does not increase.

Note that Davies (2000:64) agrees with this overall line of argument. The simple laws of physics, such as gravitation, can transform a uniform gas into galaxies that need a large amount of information to describe, but the information was 'secreted' in the gravitation field, in other words, the law or function already contained the information (:64). We are here talking about information at the statistical level, the information theory level. Davies (:254) also holds the view that 'ordinary laws' simply shuffle information around and do not create information. He does believe in the possibility of 'complexity laws' that might create new information (:259), but more on this later.

4.4.8.2 Chance on its own

Dembski's position is that chance can generate 'complex unspecified information and 'non complex specified information', but not complex specified information (1999:165). All of this comes from the definition of what complex specified information is. Dembski (:165-166) uses the random typing analogy by way of illustration: although a random document may be complex, it is highly probable that a particular sequence of characters will be repeated if the document is long enough and the sequence is also unspecified. Short sequences of characters that make sense may be present (e.g. 'god'), which is non-complex specified information formed by chance, but longer sequences are too improbable. Dembski's cut-off for attributing to chance is his 'universal probability bound' of 10^{-150} which is equivalent to 500 bits of information (:143, 166). For events with probabilities lower than this, 'chance is eliminated and design implicated' (:166). Complex specified information (CSI) is now defined as 'any specified information whose complexity exceeds 500 bits of information' and hence chance is excluded (or made extremely unlikely) by this definition (:166).

As Dembski points out, biologists in general and Richard Dawkins in particular reject pure chance as an adequate explanation for complexity (:166-167).

4.4.8.3 Law combined with chance

By now it is clear that Dembski will not give (law + chance) a chance to succeed! His argument is simply that a two-stage process, with chance operating first followed by law, cannot generate CSI since chance does not generate CSI and neither does law – it merely shuffles existing information (1999:168-169). Hence Dembski concludes that all stochastic (random) processes, such as genetic algorithms, neural nets, Darwinian mutation and selection, are incapable of creating CSI. However, the issue of the role of the environment remains and we will now consider this.

4.4.8.4 *Law and chance interacting with the environment*

As Dembski (1999:173) acknowledges, evolutionists argue that the CSI of an organism increases from generation to generation due to the Darwinian mutation and selection mechanisms bringing in *additional* CSI from the environment. Davies' complexity laws would conceptually 'wrest it [information] from the environment and etch it onto a material structure' (Davies 2000:259).

This raises the whole issue of open versus closed systems. Dembski (1999:170) formulates a *law of conservation of information* (LCI): 'Natural causes are incapable of generating CSI'. Peter Medawar has also used this concept to illustrate that deterministic laws cannot produce new information (:170). Gitt's 23rd information theorem also takes this stance (see Appendix A and Gitt 1997:79)

The implications of this 'law' for closed systems are (:170):

- 'The CSI in a closed system of natural causes remains constant or decreases.'
- 'CSI cannot be generated spontaneously, originate endogenously or organise itself.'
- 'The CSI in a closed system of natural causes either has been in the system eternally or was at some point added exogenously (implying that the system, though now closed, was not always closed).'
- 'In particular any closed system of natural causes that is also of finite duration received whatever CSI it contains before it became a closed system.'

Intelligent design adherents differ as to whether CSI was always present or was inserted from time to time, with Dembski being in the latter camp (:171).

The major thrust behind the law of conservation of information is that CSI cannot be explained reductively, by moving from the complex to the simple (:171). A closed system moves from the complex to the just as complex.

With respect to the possibility of open systems, Dembski feels that the crucial aspect of CSI is that it is holistic in that if individual items of information are added together, they do not form a new item of CSI (1999:173). The parts of the whole must not simply be added together, but must be arranged in the correct relations. Only if a top-down specification is given (as in a target sentence, for example for a set of characters) can the parts be arranged to form CSI. This is another form of the popular argument for purpose that is used against Darwinian evolution. Dembski (:174) says 'selection and mutation operate with no memory of the past or knowledge of the future' and hence the CSI that it creates must be generated in a single generation. The reason this constraint is needed is that mutation and selection cannot sustain a specification (a target pattern) over the many generations needed to achieve the specified adaptation. This argument presumes that a specification, a target that needs to be 'remembered', must exist for complexity to arise.

Dembski (1999:174) asks whether mutation and selection can generate CSI in one generation. My impression is that here a straw horse type of argument is being created that will be refuted.

If we take the position that CSI cannot be generated by natural causes, the question remains whether natural causes can use pre-existing CSI and include them in the first living organism (Dembski 1999:175). Furthermore, how can the combination of CSI in the environment and the organism be translated into further organisms with greater complexity? The flow of CSI into and out of biological systems is the issue.

Dembski's answer is that the CSI received at the birth of an organism comes from inheritance with modification. During its life, the organism acquires CSI via selection and infusion.

Modification includes mutations as in random genetic errors, plus the combination of DNA from both parents in sexual reproduction, etc. 'Infusion' here means transfer of CSI between living organisms as, for example, via the interchange of pieces of generic information between bacteria (:176).

Which of these increases the CSI? Inheritance is merely the transmission of existing information from generation to generation (in the form of DNA). Modification, including mutations of DNA, is viewed to be the operation of chance, which by itself cannot increase CSI. This leaves selection. Selection, in Dembski's words, 'introduces new information' by 'seizing on advantageous modifications' (1999:177). Note that the word *generate* is not used. Dembski again brings in Behe's argument for irreducible complexity, with the example of the flagellum of a bacterium (:177-178). How can the target be reached if selection is without purpose? Dembski (:178) says: 'The environment contains no blueprint of the flagellum which selection can extract and then transmit to an organism'. Selection can only build on partial function, but incomplete irreducibly complex systems will not function at all, and therefore full function has to be reached in one generation. The CSI of a flagellum is more than 500 bits and hence is extremely unlikely to be produced by chance in one go! (:178). Again the question is whether in fact a random walk of partial improvements can actually get you to a complex, but not predetermined end-point?

Finally, let us discuss infusion. Dembski (1999:179) distinguishes between *biotic* and *abiotic infusion* and correspondingly between *endogenous* and *exogenous information*. Biotic infusion is the infusion of information from one organism to another, whereas abiotic infusion comes from non-biotic sources. Endogenous information is biotically infused information and exogenous information is abiotically infused information. If we trace back in time, then somewhere the first living organisms must have occurred and at that time abiotic infusion must have taken place, creating exogenous information. This is again a reframing of the question: What is the source of biological information? This question also fascinates Davies.

4.4.8.5 Evolutionary biology from an information perspective

The aim of evolutionary biology is to understand the genesis and development of life and to Dembski the key feature of life is the presence of CSI (1999:180). Dembski (:180) sees a limited role for Darwinian mutation and selection as a mechanism for 'conserving, adapting and honing already existing biological structures'. This is the so-called micro-evolution role. Dembski denies that Darwinian evolution has the information resources to produce irreducibly complex biological structures. The major issue is to understand where the exogenous information that was originally infused abiotically comes from. In simpler words, how did information come to reside inside living things?

In essence, Dembski sets up a chain of questions tracing back to the origins of information. How is abiotically infused CSI transmitted to an organism, and where did this information come from? If this information resides in a non-biological system, how did it get there? This quest can end in several different ways. We might find that we cannot get beyond biological organisms, stopping dead at an irreducibly complex biological system. We could get stuck at an abiotic source of exogenous information; Dembski (:181) mentions the clay-template theory of Cairns-Smith[30]. Again Dembski asks: Where did the information in the clay-template come from? We could trace the information all the way to the Big Bang as Davies did, but we would still have to show how information was created and transformed along the way. The creationist would stop at the direct intervention of God as the source of information. Dembski (:182) views this as 'scientifically sterile' unless you can show that biological information could not have come from anywhere else, and even then the how question remains - How did God do it?

Dembski (1999:182) demands that an evolutionary biology reconceptualised in information-theoretical terms must trace information pathways in explicit detail, with rigor, based on empirical evidence, and they need to conform to biological reality. The last point is aimed at the 'nebulous informational pathways sketched by Stuart Kauffman' which reside in a computer (:182). These criteria favour the CSI theory of course. Dembski feels that information theory is flexible enough to be able to handle all the evolutionary mechanisms that have been proposed and will, in fact, show clearly the information-theoretical constraints that they are subject to. Dembski has done this for the Darwinian mechanism. Dembski's main issue is that:

> all reductionist attempts to explain information in terms of something other than information will have to go by the board. Information is *sui generis*. Only information begets information.
>
> (Dembski 1999:183)

[30] This theory is discussed in Subsection 4.3.6: *From the first living thing to microbes*.

4.4.9 An appraisal of Dembski's approach

4.4.9.1 Introduction

Using Barbour's terminology[31], Dembski follows a 'natural theology' approach rather than the 'theology of nature' approach that is popular currently.

To what extent do Dembski's intelligent design arguments succeed as a *two-pronged attack* against naturalism? The two prongs are a 'scientific and philosophical critique of naturalism' and a 'positive scientific research program' (Dembski 1999:120).

4.4.9.2 The critique of naturalism

Is Dembski's approach the right way to attack naturalism? Pennock (2000:183) sees his approach as a continuance of a classic creationist argument in which the question is formulated as if there were only two mutually exclusive options, in this case either scientific naturalism or intelligent design. The next step is then to argue that scientific naturalism has many failings and that therefore intelligent design, as the only alternative, must be correct. This is one reason for the strong attack launched by Dembski on theistic evolution, since it undermines this either/or dichotomy. Howard van Till, a theistic evolutionist, as quoted by Pennock (:183), is against those who 'preach the gospel of either/or-manship'. Pennock (:183) suggests that 'this new dual model approach misunderstands the nature of the scientific issue in as fundamental a manner as did the old version'. Pennock (:190-191) distinguishes between ontological or metaphysical naturalism and methodological naturalism. Ontological naturalism makes claims about what nature consists of, while methodological naturalism commits to a set of methods as being the way to discover how the world works (:190-191). As we have discussed, Dembski (1999:103) talks of *scientific naturalism*, which is the location of 'the self-sufficiency of nature in the natural laws of science'. This corresponds to *ontological naturalism.* Dembski (:119) sees *methodological naturalism* as the premise that science must be limited strictly to the study of undirected natural processes. Pennock (2000:191) makes the point that new evidence

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[31] Please refer to Subsection 6.2.1 where a 'theology of nature' approach is discussed as part of the 'Integration' category of Barbour's four-fold typology of the relationship between science and religion.

will cause the methodological naturalist to revise both method and any substantive claims, if 'doing so would provide better evidential warrant'. Dembski wants to revise the method by breaking out of the naturalist's prescription that science deals only with *natural causes* and wants to include the study of *intelligent causes* as well (:105). Dembski does want to provide 'better evidential warrant' via the notion of CSI as empirical evidence of design.

Pennock (2000:192) makes the point that the creationist's reasoning seems to be that 'because naturalism rejects continuing divine intervention, it does *implicitly* deny God's existence, but this conclusion follows only if one has a particular conception of divine power'. As Pennock (:192) argues, many concepts of God such as deism, the view that we cannot know the nature of God, the view that God only intervenes on the spiritual level, are compatible with both ontological and methodological naturalism. I would add that certain varieties of theism are also compatible with naturalism. One does not necessarily have to perceive of God as absent if one agrees with naturalism.

Dembski's critique against naturalism is thus intimately tied to his concept of God. Therefore his objective is that evidence of God's interaction with the world must be produced since, if God's interaction is hidden, God's existence may even be affirmed by scientific naturalists, but this God will be 'a superfluous rider on top of a self-contained account of the world' (:104).

Therefore it seems to me that, in reality, Dembski's two-pronged attack only has one prong. He is playing by science's rules, using science's methods to try to provide empirical, scientific evidence for intelligent design.

Finally, Pennock (2000:210-213) argues that Philip Johnson, in his attack on scientific naturalism, is following a post-modern approach. Pennock (:212) sees Johnson's book, *Defeating Darwinism*, as a creationist manifesto that 'incites believers to [quoting from Johnson's book] "step off the reservation" and escape the "oppression" and "domination" of the materialist rules" to which the Darwinian "intellectual elite" have forced them to "submit"'. The contention is that science is seen as the only source of objective knowledge simply because of the power of the scientific establishment which defines what knowledge is. This is a post-modern claim that human knowledge is relative. Dembski (:118) follows Johnson's line in that he agrees with Johnson that 'science is the only universally valid form of knowledge in our culture'. However, as Pennock (:212-213) says, creationists go beyond post-modernists and assert that while 'human reason by itself is impotent' ... 'God's divine revelation saves us from relativism by providing us with absolute truth in Scripture'. So Johnson uses post-modern language to attack the position of power of the scientific narrative, but then goes on to talk of 'Truth with a capital T' (Pennock 2000:213). It seems that creationists find it acceptable to use post-modernism against their opponents, but not against their own position. One can also ask what kind of truth is being used here. Is the biblical message seen as final, absolute truth or as redemptive truth?

4.4.9.3 The scientific attack on evolution science

Dembski's approach in this prong of the attack is that Darwinian evolution must be attacked as, first and foremost, an empirically inadequate scientific theory and not because of its supposed incompatibility with some system of religious belief (Dembski 1999:112). Dembski (:111-112) rejects 'theistic evolution' as an approach since it does not command any respect from atheists because the theism part of 'theistic evolution' is superfluous. To him the presence of 'evolution' in 'theistic evolution' is objectionable since it needs to be attacked and not acknowledged as the full scientific picture of the biological world.

Robert Russell (1998:192) agrees that theistic evolution, if based on chance as epistemic ignorance, either means nothing, since natural law explains everything in effect, or, one is driven to an interventionist position in which God must intervene, causing a gap in the closed causal order. However, he disagrees fundamentally with the attack on Darwinism as a scientific theory. Russell (1998: 192-193) regards this approach as:

> playing directly into the hands of the atheist, since they implicitly agree that it is Darwinism, and not its atheistic interpretation, which must be attacked. In doing so they ignore the fact that theistic evolution offers the real attack on atheism by successfully giving a Christian interpretation to science - thus

undermining the very assumption they share with atheists, namely, that a Darwinian account of biological evolution is inherently atheistic. Not only does this abandon vast realms of biology to the atheistic camp, it implicitly undercuts the integrity of those Christians who faithfully pursue research in mainstream biology, as well as the vast number of Christians who, while not being biologists as such, accept it and give it a Christian interpretation. How much better would it be if those promoting "creation science" and "intelligent design" would attack atheism instead of evolutionary biology!

Dembski attacks not only the adequacy of the Darwinian mechanism, but the whole of science. It appears that he wants to expand the boundaries of science. Dembski (1999:105) wants to break out of the closed causal system, to replace the terminology of natural versus supernatural with natural versus intelligent causes. Science must admit the existence of intelligent causes on an empirical level. Dembski's contention is that the distinction between intelligent and natural causes 'has underlain the design arguments of past centuries' (:105). To ask whether an intelligent cause works within or outside nature is a separate question to Dembski (:105). However, he does not answer this question!

In order to try to address one of Russell's concerns, namely that intelligent design leaves biology to the atheists, Dembski stresses again and again the empirical basis of his argument, so that it forms part of science.

With regard to intelligent design's search for legitimacy, it can be stated that science provides it! The battle is being fought on science's terms, empirical grounds, because 'science is the only valid form of knowledge in our culture (Dembski 1999:118).

Is Dembski's own approach not also reductionist since all laws of complexity are thrown out and only simple laws can be used? Davies and Dembski (1999:171) would agree that reductive explanations are not sufficient, but Davies will not replace them by inferring design and hence intelligent agents. Davies would probably move to laws of complexity.

In general, Dembski acknowledges that his argument cannot lead directly to the God of the Bible. Even an agnostic stance is compatible with his argument. His empirically based argument cannot provide strong support for theism.

4.4.9.4 A critique on a scientific level

Holder (2000:181), as a Bayesian, is dissatisfied with Dembski's approach since it does not confirm his hypothesis, it simply eliminates others. According to Holder, Bayesianism 'directly compares the probability of competing hypotheses, given E [an event], in terms of their (mathematically well-defined) explanatory power and prior probability'.

On another level, probabilities are relevant as well. If one starts with the complex end-product and reasons back in a step-by-step fashion to the humble beginnings, then the probability of each step seems manageable by simple laws plus chance. It does not look as improbable as when Dembski demands that the leap must be made in one generation against impossible odds. Dembski would obviously reply that the simple laws have no direction, no end-goal or purpose, and hence would not arrive at the complex system. If the argument is that the issue is just how to arrive at *any* complex destination rather than a particular one, then the issue of irreducible complexity will be brought up again. Dembski's argument is that one could never arrive at an irreducibly complex system since the systems along the way are not functional. This argument has, however, been vigorously contested since small advances could confer an incremental advantage in the context of the battle for survival in nature.

4.4.9.5 The limited nature of Dembski's model of design

As stated previously, Dembski has been criticised for defining design as that which is left when chance and regularity have been eliminated (Holder 2000:180). This criticism comes from Holder's review of Dembski's book, *The Design Inference*. Holder quotes Dembski as saying that design 'asserts what an event is not, not what it is' and therefore design is preliminary to attributing intelligent agency and makes it plausible. In *Intelligent Design*, Dembski (1999: 133) presents his complexity-specification criterion as a flowchart with three decision nodes and calls it an 'explanatory filter'. The questions are, in sequence:

Is an event, or an object:

- *Contingent?* (if not, then the explanation for the occurrence of the event is *necessity*)
- *Complex?* (if not, then the explanation is *chance*)
- *Specified* ?(if not, then the explanation is *chance*)

If all these explanations have failed, the only remaining explanation is *design*.

Pennock (2000:95) points out that natural law and chance are not mutually exclusive since there are 'statistical and deterministic laws'. Law and design are also not mutually exclusive since we can explain via the laws as well as in terms of the specific intentions of the designer, as evidenced by the natural theology of the clockwork universe (:95). So intentional design can be a viable option even if the first two filters have not been passed. Pennock's position is 'that we cannot identify design by a two-step process of elimination but rather must have positive evidence for it, based for example, on knowledge of specific design intentions and the possibility of their having operated through some causal intervention in the situation under consideration' (:95-96). This seems quite a high hurdle to jump in terms of the 'extra' knowledge required and the possibility of causal intervention is always there if statistical laws operate. Pennock does mention the issue of specification as part and parcel of design and this is quite an interesting issue.

By 'specified', Dembski (1999:132-133) means that a certain *type* of pattern enables one to infer design in the presence of complexity. This pattern is not ad hoc and must be *independent* of the particular event it describes. Dembski (:133) calls this relation of independence *detachability* and such patterns are said to be *detachable*. If we are given an event and a pattern describing it, then a detachable pattern is one that can still be constructed from the range of possible events without knowing which of these possible events actually happened (:133). In order to construct this pattern Dembski (:138) introduces the notion of the need to use additional side information in order to eliminate chance and to detach the pattern from the event, thus making the pattern a specification. To avoid the contention that side information is ad hoc, Dembski (:138-139) places two conditions on side information, namely: conditional independence and tractability ('do-ability').

Conditional independence, a concept from probability theory, is epistemic independence, i.e. knowledge of the side information must not affect the knowledge of the occurrence of event E. This means that the probability of an event must not change if we take the side information into account.

The tractability condition requires that the side information enable the construction of the pattern D to which E conforms. The meaning of 'enables' is described by complexity theory, a generalisation of computational or algorithmic complexity theory, which 'assesses the difficulty of tasks given the resources available for accomplishing those tasks' (:138, see also Davies 2000:116-120).

These two conditions are a means of ensuring that the pattern is constructed from an event without 'recourse to the actual event' (Dembski 1999:139). Specifications are then these non-ad hoc detachable patterns. Dembski uses these conditions, it seems, to guard against allegations that an event can be interpreted in an ad hoc fashion to suit one's purposes (as in attributing intelligent design!).

Chaitin's work[32] shows that we will not detect all the patterns that are non-random since we cannot prove that a pattern is random. This is fine since avoiding false negatives is not what Dembski's problem is, rather it is false positives that are a problem. Are these two conditions sufficient to distinguish ad hoc from non-ad hoc?

Where does the side information come from? The problem is that an intelligent agent could simply project an inappropriate pattern onto the data. The person observing the data could be the source of the side information. Chaitin's work comes in here as well, in the sense that a pattern of events may look highly random, but may not actually be

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[32] As discussed in Subsection 4.2.4.1: *Syntax*, Chaitin has shown that it is in fact theoretically impossible to determine whether a sequence is random, because there is no algorithm that can do this (Gitt 1997:126).

so. A pattern that appears to be intractable could have been caused by an unknown law. If we do not know the action of the law, the pattern of events may look highly improbable, but actually the law was in action. Dembski would say that the Darwinian mechanism is too simple to be this kind of law.

We can look at the explanatory filter from the other side, from the bottom-up as it were, and ask what things would look like if design was present? This is then in terms of Dembski's claim that intelligent design is a research programme investigating how the designer went about it and how the design works. Side information enables us to detach the pattern and create a specification. So, only when we have certain knowledge can we understand the cause of the pattern. Dembski admits that the naturalist's critique is that all this knowledge comes from the human domain. Dembski states that we detect intelligent agency by examining the choices that have been made, specifying one out of many possibilities (1999:145). Although Dembski contends that intelligent design says nothing about the nature of the designer (transcendent or not), we do have to consider criticisms of the overall pattern of design. Eldredge (2000:144-145) proposes a test of a different kind, namely: Does the design history of human objects 'reveal a simple nested pattern of similarity, as evolution has produced in the biological realm?' His answer is no, it does not and therefore biology does not point to a human designer. Eldredge (:144) points out that the creationist's response is that the Creator was 'merely efficient in using the same blueprint for the separately created basic kinds'. Eldredge (:146), as a designer, would rather have used the same good design idea *anywhere* and not have restricted it to 'what someone in retrospect might be tempted to identify as separate lineages'.

Pennock (2000:146) puts forward a similar type of argument in which he examines the nature of explicitly designed languages such as Esperanto versus the (presumably) evolved languages that exist today. Esperanto is structured in a regular way with simple rules, whereas natural language is a 'jerry-built' jumble (:146). His conclusion is that natural languages 'are not formal constructions imposed from on high' but 'developed into and from one another over time, through piecemeal constructions and unplanned transformations' (:146). This tells us something about the nature of unintentional human designs vs intentional human designs. God could intend to design this way, so all these arguments cannot prove that God did not design, it can only show that the end-results are like those produced by unintentional processes. Pennock (:246-249) analyses the creationist response to what he calls the 'imperfection argument' against intelligent design made by evolutionists such as Gould. The argument is basically that 'odd arrangements and makeshift adaptations' are positive evidence for evolution since these are to be expected due to the constraints of having to work with what you already have (:247). Pennock distinguishes between using this pattern as a positive argument for evolution and using it as a negative argument against intelligent design by stating that a designer God would not have designed this way. He agrees with creationists that this is a breach of methodological naturalism, since you cannot test 'what would or would not be sensible from God's point of view' (:247). Pennock (:248) quotes Michael Behe: 'Another problem with the argument from imperfection is that it critically depends on a psychoanalysis of the unidentified designer. Yet the reasons that a designer would or would not do anything are virtually impossible to know unless the designer tells you specifically what those reasons are.' Pennock (:249) agrees with this argument, since 'we are in no position to psychoanalyse God or any other supernatural intelligence' but the sting in the tail is that this insulates the design argument against the imperfection argument, but does not attack the positive argument for evolution. It remains a negative type of argument, rather than offering positive evidence, and Pennock (:249) calls the design inference 'just another form of the God of the gaps argument'. Dembski would disagree, but the point is that it is not that easy to remain at the level that Dembski proposes, the empirical level of CSI as evidenced in systems. The grand sweep of cross-comparing these systems, tracking their relationships and common characteristics, leads one to questions about what type of design practice it is that we see here. Therefore, the positive evidence offered by the design inference seems thin and the argumentation tends to become negative.

A more direct attack would be against the fundamental notion of complexity and specified purpose. Dembski's argument would fail if complex[33] systems could be seen to be achieving some purpose. Pennock (2000:106-107, 262-263) mentions artificial life environments in which 'digital organisms' evolve that show signs of 'intelligence',

[33] Systems less probable than Dembski's 'universal probability bound' of 10^{-150} (as discussed in Subsection 4.4.5)

purpose and behaviour that were not designed in the normal sense. Cellular automata, which are also capable of complex and purposeful behaviour, are discussed in the next Chapter[34]. These systems are becoming more complex and it cannot be ruled out that Dembski's probability bound could be exceeded in the near future.

We have now covered the different approaches of Gitt, Davies and Dembski to the new arena of the divine action debate, namely biological information. In the next Chapter we step back and survey the many different ways that information concepts have been used in science, in theology and in the interfaces between various contexts.

[34] in Subsection 5.6.7.5

5 The many different uses of information concepts and theories

5.1 Introduction

An interesting overview of the uses of information in science and theology is presented by the Third European Conference on Science and Theology, held in 1990 (Wassermann 1992). The theme of the conference was 'Information and Knowledge in Science and Theology'. The broad themes that can be distilled from the large variety of papers presented are used to structure this discussion.

The concept of information is being used in many diverse contexts, ranging from the physical sciences, life sciences and the modern information sciences, to the humanities and the 'meta'-sciences such as theology and philosophy (Wassermann 1992:2). Information is used not only in different contexts, but also in the *interface* between different contexts. So we find information in the interfaces between contexts as diverse as theology/science, physical/life science, physics/philosophy, sociology/communication science and linguistics/education (:2).

Along the same lines, we can note that the theory of communication also deals with what happens in the interface between two contexts, that of the sender and that of the receiver, with information being transmitted via the communications channel between the two contexts. The problems associated with the interpretation of the message are also well known, and are studied, for example, in the field of hermeneutics.

Another broad area of interest is the role that information plays in connecting the hierarchy of organisational levels that stretch from the fundamental entities of matter, energy and information, to the level of communities using language. The reach is thus from the quantum world to the human world and the spiritual world. Along the way, several crucial interfaces are crossed or 'jumps' are made, e.g. the jump between non-living and living, animal and human consciousness, etc.

On a more specific level, communication and information theories and concepts have been used to:

- bridge the gap between science and theology (by developing a common language and by extending the reach of science)
- enrich our concept of God
- clarify our concept of what life is
- clarify our concept of what being human is
- link the hierarchy of organisational levels
- understand God's interaction with the world.

Each of these areas will now be discussed, but the main focus will be on the issue of bridging the gap. Along the way, the broader issues will be touched on as well.

5.2 Bridging the gap between science and theology

5.2.1 An approach to developing a common language

At this point we need to introduce some thinking about the fundamental differences between science and religion, as well as the surprising commonalities. The assumption that can serve as the basis for bridging the gap is that there is only one reality and that ultimately science and religion are both ways of trying to understand the very same reality. Although the methods may differ and the subjects may seem quite different, at some point as each "delves" deeper and deeper, science approaches the limit questions and religion has to deal with the mysteries of the reality that science has uncovered. The limits of language are then close at hand and, as McGrath (1998:34) formulates it, science and religion find themselves facing the 'issues of representation and conceptualisation', and, in trying to tackle these issues, similar approaches are followed to try and find answers. We use language to try to understand the world, so the issue is perhaps not so much the search for a common language, but the fact that language is what both scientists and theologians have in common. McGrath (:34) uses this as his point of departure, namely the way in which reality is 'apprehended, investigated and represented' by religion and science.

Mary Hesse follows a slightly different route[35] but in the end the central issues remain the same: How can we talk about the world? How can we use words to refer to something that is beyond all words? Then we can place information concepts in perspective (possibly in the centre!) as the way in which we describe order in the complexity of the world. McGrath (1998:35) asks: Why is the world intelligible? We can phrase this as: Why does order that can be interpreted into information exist in the world?

Why would we specifically use the concept of information and not other scientific concepts? Information has been regarded as a 'hinge category' between science and theology since it plays a role in both science and theology (Van der Lubbe & Laurent 1992:85). Our discussions of Gitt, Dembski and Davies' work has covered some of the ways in which information concepts are used. In a more cynical mode, we can say that the concept of information has many interpretations and uses and is therefore ideally suited to metaphysical and theological speculations!

Myth, model and metaphor play a central role in developing and expressing our understanding of the world and of religious matters. In the dialogue between science and religion, these issues have a long history and we will discuss them later[36].

Before we address the interface between science and theology, we take a look at the use of information concepts at the interface between two *scientific* contexts. In this case the aim is to try to understand the *nature* of reality, specifically in our focus area of evolutionary biology.

5.2.2 The biological use of information concepts from physics

5.2.2.1 Introduction

John Maynard Smith (2000a,b) has written what he calls a 'natural history of the concept of information in biology'. He has done this because information is a central

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[35] See Subsection 5.2.3: *Myths, Models and Metaphors.*

[36] Subsection 5.2.3.

idea in contemporary biology, and indeed to such an extent that 'developmental biology can be seen as the study of how information in the genome is translated into adult structure, and evolutionary biology as how the information came to be there in the first place' (:177).

5.2.2.2 The analogical use of information concepts

Smith (2000:178-181) discusses the *analogical* use of information concepts. He makes the point that biologists use informational terms, such as transcription, translation, code, redundancy, editing, messenger and proofreading, as technical terms all the time. The similarities between the meanings as applied to human communication and genetic transcription are close, and that is why these terms are used by biologists. Smith (:178) distinguishes between two uses of analogies in science:

- To describe a formal and exact *isomorphism* between two different physical systems
    - An example is the building of an electrical circuit that models exactly the behaviour of the modes of vibration of a mechanical system.
- To describe a qualitative *similarity* between two systems in order to provide insight into an unfamiliar system by comparison with a familiar system.
    - For example, Harvey's recognition that the heart can be viewed as a pump.

Smith (:179) does warn that a qualitative analogy can 'mislead as well as illuminate'.

To Smith it is not surprising that analogies from information theory should have been used by biologists since scientists need to get their ideas from somewhere, and during the twentieth century the information sciences have been prevalent.

With respect to criticism that the analogy does not hold in the case of genetic transcription (see below), Smith's position is that not only does the analogy with the transmission and encoding of information hold, but also a formal isomorphism holds (:181).

Words, encoder, message in Morse code, transmitter →	Channel→	Receiver, decoder, message in words
Words, DNA, message in messenger RNA →	Channel→ (chemical process)	Ribosome as decoder, protein as message

The question, as he sees it, is: Where did the information in the DNA come from? The analogy that exists here is between the human who converts meaning into words that can be encoded further and natural selection which produced the sequence of bases in the DNA that specify a protein that carries 'meaning' for the organism in being functional. Smith (2000:181) says: 'Where an engineer sees design, a biologist sees natural selection'. The issue is therefore not the analogy with respect to the transmission of information, but the analogy with meaningful information. We have seen that this is a consistent criticism, since information theory (in Shannon's formulation) does not deal with meaning but with the quantity of information, or with 'what you *could* say rather than what you *do* say' (to paraphrase Shannon as quoted by Smith 2000:181). Hoffmeyer[37] (1997) says that biologists and physicists are talking about different things when they use the word information, since biological information always serves a purpose and is not the same as mathematical information. Furthermore, biological information is inseparable from context. For example, DNA has to be interpreted by a fertilised egg, it cannot interpret itself. In biological terms, Smith (2000:181) formulates the 'What do you say?' question as: 'How does genetic information specify form and function?'. So there are questions regarding meaning at both ends of the communication process.

5.2.2.3 Using information in a quantitative sense

In terms of the quantification of information, Smith (2000:185-187) makes the interesting assertion that information theory can be used to quantify evolution at the genetic, selective and morphological levels.

[37] This article was accessed via the Internet and a page reference is not available.

At the *genetic* level the capacity of the information carrier, DNA, is approximately two bits per base, but it is reduced somewhat by the presence of so-called 'redundant' or repetitive DNA[38].

At the *selective* level the question becomes: How much selection is needed if you start with a totally random sequence of bases? If selection is between the two halves of a population, which corresponds to there being two choices which is equivalent to one bit, then two bits of selection are needed to program each DNA base. Leaving aside questions of purpose and the fact that evolution does not normally start from a random sequence, a crude estimate of the amount of selection needed to program an existing genome can be developed. Smith estimates that the quantity of information in the human genome could easily have been programmed by selection ten times over in 5 000 million years, due to the fact that we can allow for 20 generations per year since for most of that time our ancestors were quickly replicating microbes. This estimate would probably be affected by the newly discovered fact that the human genome contains only approximately 30 000 genes as opposed to the 100 000 plus genes as thought previously. There are, of course, people who would dispute this argument, especially Dembski with his cut-off for attributing to chance, or his 'universal probability bound'[39] of 10^{-150} which is equivalent to 500 bits of information or, in the case of the human genome, 1 000 bases.

At *the morphological* level Smith's position is that the genome can contain enough information since it is a set of instructions, a recipe, on how to make the adult form and not a description, or blueprint, of the adult form (Smith 2000:187). This leads to the issue of the use of information terms in developmental biology and specifically the question of whether the genome can be regarded as a developmental program. Here we move into the computer with its programs as the basic analogy, the genome being the program with its genetic code and the translating machinery of the cell being the computer. Smith (:187-188) highlights the complexity of the developmental process with its complex hierarchy of genes regulating the activity of other genes, which is

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[38] Please refer to Section 4.2 on Gitt's work as well. Four different bases = four choices = two bits of information).

[39] See Subsections 4.4.5 and 4.4.8.2.

described as genes 'signalling' other genes. Signalling is the new central concept in developmental biology.

5.2.2.4 Intentional causes and information as carrier of meaning

Smith makes an important distinction between the *types* of information talked about in biology. This distinction originates with Dretsky's concept of information (Smith 2000:189). When two variables, say A and B, are correlated, then B is the carrier of information about A. For example, if rain occurs whenever black clouds appear, then the type of cloud indicates when it will rain. These correlations are dependent on the laws of physics and on the local environment (e.g. presence of mountains, etc. in this case).

This ties in with the 'nature versus nurture' debate as well. Smith draws a distinction between two types of causal chain, namely genetic (nature) and environmental (nurture). Differences due to nature (genetic information) are likely to be inherited (transmitted), while those due to nurture will not be inherited. Informational language has been used to describe genetic causes and not environmental causes. Smith (:189) argues that the reason behind this is that the concept of information is used in biology 'only for causes that have the property of intentionality'. When a biologist says that B carries information about A, what is being implied is that B has a certain form because of the information it carries. The example that Smith uses is that a DNA molecule has a particular sequence of bases *because* it codes for a particular protein, whereas a cloud is not black because it predicts rain, but is intrinsically black due to the presence of a dense multitude of water drops. Note that here we again encounter the symbolic nature of the DNA code: the correspondence between a particular three-base sequence and the amino acid it codes for is *arbitrary*. However, once the code has been established, the protein and the code are linked into a feedback loop. Smith (:190) attributes this element of intentionality to natural selection.

In order to illustrate what is meant by intentionality in this context, Smith (2000:190) uses the example of genetic algorithms[40]. A software programmer, for instance, can take two approaches to write a program to play a game. Rules can be invented for the game and each rule can have one or more parameters that can be specified via a bit string. Weightings can be given to the different rules to allow the program to determine which rule determines the next move in the game. The programmer can now perform a genetic algorithm experiment in which the game is started off with a random selection of parameter strings, followed by play in which the most successful strings are retained and then randomly mutated before the next round of play. Ultimately, a successful program will evolve. Alternatively, the programmer could design successful strategies and rules and incorporate them into a program. With this type of program, we would have no problem in saying that it carries information in the form of its rules and expresses the intentions of the programmer. By analogy, the program created via genetic algorithms contains information in the bit strings representing the parameters that have been programmed by selection and not by the engineer. Smith (:190) states that the justification for this analogy is that 'presented with a bit string and the moves that it generated, it would be impossible to tell whether it had been designed by the engineer directly, or by selection between genetic algorithms'.

Smith (2000:190) then draws the parallel with biological evolution in which the genome codes for proteins and results in a living organism which then is selected via survival and reproduction in a specific environment. To summarise, Smith (:190) says:

> this analogy justifies biologists in saying that DNA contains information that has been programmed by natural selection; that this information codes for the amino acid sequence of proteins; that, in a much less understood sense, the DNA and the proteins carry instructions, or a program, for the development of the organism; that natural selection of organisms alters the information in the genome; and finally, that genomic information is 'meaningful' in that it

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[40] Please refer to Gitt's arguments in Subsection 4.2.6.2: *Genetic algorithms*. See also Subsection 5.6.7.8: *Computational neuroscience*.

generates an organism able to survive in the environment in which selection has acted.

Smith (2000:190-192) admits that a weakness of the programming and biological models is that they do not indicate the *origin* of the rules. The programmer chooses the rules of the game and the laws of physics and chemistry determine what happens in nature. Higher-level rules exist as well, particularly in developmental biology, with regulatory genes controlling the parameters of these rules.

We now redirect our attention to the problem of distinguishing between genetic and environmental causes; why informational language is used to describe genetic causes and not environmental causes. This is due to the fact that biologists see fluctuations in the environment as a source of noise[41] in the system and not as information. The laws of physics and chemistry do not change but the environment can. An example of adaptation to environmental changes is developing a suntan after exposure to the sun. One does not inherit the suntan itself, but the genetic mechanism that causes it to appear in response to sunlight.

5.2.2.5 A summary of Smith's natural history of the use of information concepts

Finally, Smith's position can be summed up as follows:

- The word 'information' can be used with or without semantic or meaning implications.
- If used without semantic implications, information means simply covariance between two systems, between a signal and its source.
- We can use the concept of intentionality to expand on what we mean by semantic implications.
- The notion of information as used in biology is that of intentional information.

[41] In Shannon's model a noise source refers to signal noise that can occur in the channel between sender and receiver, which results in distortion of the message (see Subsection 2.2.3:*Models of communication processes*).

- Natural selection produces the intentional information that is captured in the genome.
- The information in the genome has meaning, is intentional, since it generates an organism able to survive.
- The genetic code is arbitrary or symbolic (according to semiology, signs are arbitrary!).
- Genes and regulatory proteins can be said to carry information since there is an evolved receiver (the cell's translation machinery) of the message they carry.
- A test for intentional or meaningful information is whether the concepts of communication error and of misrepresentation make sense. And, yes, this does make sense in biology since there is a sender and a receiver, as well as a message that can be misunderstood.

The analogy between the use of information in evolutionary biology and in human communication is based on the fact that in human communication there are intelligent and intentional senders and receivers. Smith views the genome as having intentionality since millions of years of selection have produced a genome that causes the development of organisms able to survive in a certain environment. The intelligent sender can thus be viewed as the combination of the genome and the selection pressures forming a system that communicates to future generations. The message is: 'These qualities have worked in the past'. If you look at the information itself, Smith's position is that intelligent design and natural selection produce similar results (2000:193-194).

5.2.2.6 Responses to Smith's study of the use of information concepts in biology

Several important issues come to light in the responses by biologists to Smith's so-called *natural history* of the use of the concept of information in biology:

1. Does the model of the *communication* of information that Smith uses hold for complex biological systems?

Smith assumes a sender (DNA) and a separate receiver (the cell's translation machinery). He also uses a program analogy but admits that it is not particularly helpful since the way in which genetic information 'is responsible for biological form is so different from the way in which a computer program works', although 'it is a lot nearer the truth than the idea that complex dynamic systems will generate biological forms "for free" ' (Smith 2000:192).

Connectionist models in cognitive science show that a system capable of generating complex outcomes need not necessarily divide into elements that carry information and elements that recognise and use that information. The brain is a good example[42]. Connectionist architectures blur the distinction between data structures and programs that use the data[43] (Sterelny 2000:200). Smith's use of the programming analogy seems to endorse the split between data and programs since that is how normal programs work. However, genetic algorithms may blur the distinction as well since the program, or at least parts of the program, becomes data that is altered.

Peter Godfrey-Smith (2000:203) responds to Smith's view that there are special processes in biology (in which genes participate) that have an arbitrary or symbolic nature, in which there is no necessary connection between the form of a causal factor and its effect. He makes the observation that it is difficult to distinguish between processes 'that involve an elaborate "interpretation" of a causal factor and those that do not', since 'all the causal factors within cells tend to connect to complex networks of processes, so when do these networks count as 'interpreters' and when do they not?' (:203).

2. A more general question is whether information concepts and their framework continue to be of *explanatory* relevance in contemporary biology (Sarkar 2000:208).

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[42] The fact that there is no distinction between hardware and software in the brain is discussed in Subsection 5.6.7.7: *The brain.*

[43] Cellular automata have a connectionist architecture (see Subsection 5.6.7.5). The ability of cellular automata to produce programs, is discussed in Subsection 5.6.7.8: *Computational neuroscience.* A general introduction to connectionist models or neural networks is given by Paul Cilliers in Chapter 2 of his book *Complexity and postmodernism* (Cilliers 1998:25-36).

Sarkar (2000:209) distinguishes between the *heuristic* and *substantive* uses of a concept or framework. His definition is that 'if something plays a role in the construction of some scientific entity, that role is heuristic, if it explicitly occurs in that entity, that role is substantive' (:209). Sarkar agrees that information concepts played a heuristic role in genetics in the past, but denies that they play a substantive role. In addition, three different concepts of information have been used in genetics, namely cybernetic, communication-theoretical, and semantic[44] (:209). Cybernetic information is what we would call feedback in self-regulating systems and is a functional definition of information – information is defined by what it does and there are no structural restrictions placed on the information carrier. Semantic information is presented by Sarkar as having to do with specificity and semioticity (how x can contain information about y). Communication-theoretical (Shannon) information and semantic information concepts both impose some structural constraints. Sarkar's view is that cybernetic information is of little relevance to developmental biology (:209). While the communication-theoretical or information theory concept of information has some relevance in the context of the sequencing of the genome, Sarkar's claim is that the important concept in biology is semantic information as used in this context, i.e. when we say that DNA contains 'information' for producing proteins and organisms.

In order to get to the issue of how information concepts can be used to explain, we have to follow Sarkar through his breakdown of what semantic information is. He (:210-211) presents what he calls two locutions:

- *'s contains information for σ'* (A DNA sequence contains information for a protein.)

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[44] These information concepts map onto the five main points of view of the communication process (Fauconnier 1987:89):

- a psycho-philosophical view of the relation symbol-meaning-communication
- a cybernetic systems-theoretical view
- a socio-psychological view
- a pragmatic view
- a symbolic-interactionist view.

(Refer to Subsection 2.2.3: *Models of Communication Processes* for more information.)

- *'only s contains information for σ'* (Only DNA contains biological information - DNA is a program for creating organisms.)

In order for *'s contains information for σ'* to hold, Sarkar contends that two criteria must be satisfied, namely differential specificity and semioticity:

- The *differential specificity* criterion is: if **s** is different from **s'**, then σ must be different from σ'. Although this criterion does not quite hold due to the redundancy of DNA and our ignorance of the role played by the 'non-coding' regions of DNA, we can say that parts of the genome carry information in this sense.
- In terms of *semioticity*, **s** can be interpreted as a sign for σ' in the sense that the theory that provides the mechanisms by which **s** produces σ allows that an **s'** different from **s** could have been the sign for σ' (Sarkar 2000:210). Smith referred to the 'arbitrary or symbolic nature' of the genetic code for proteins. This criterion 'seems to deny even the mild determinism' invoked by the differential specificity criterion (:210). The issue here is that we need to understand *how* **s** is a sign for σ, how it can be possible that mistakes can occur. Sarkar feels that it is unnecessary for Smith to adopt the additional criterion of intentionality, since semioticity captures the sense in which **s** is about σ. Smith's response is that 'if signals are to be adaptive for the organism, than [sic] there must be an evolved receptor of the signal as well as an evolved sender' and 'symbolic signals' ... 'acquire their meanings from natural selection' (Smith 2000:215). Remember that Smith views the genome as having intentionality since selection has produced a genome that causes the development of organisms able to survive in a certain environment. The signs are apt for a certain environment. The question that needs to asked is: Which concept of semiotics are you working with here – De Saussure's structural linguistics or Peirce's theory of signs[45]?

[45] See Section 2.3: *The biological roots of information - from biosphere to semiosphere.*

In order for the second locution, *'only s contains information for σ'*, to hold, Sarkar (:211) requires an additional criterion to be satisfied, namely reverse differential specificity.

The *reverse differential specificity* criterion is 'if σ is different from σ, then s must be different from s'. If the DNA is different, the protein must be different. According to Sarkar, this criterion is routinely violated in eukaryotic genetics, for instance when 'alternate splicing allows the generation of two different proteins from a single DNA sequence' (:211).

Sarkar's conclusion is that 'we cannot maintain both that there is a conceptually respectable concept of information in genetics and that the genomic DNA is the sole purveyor of information' (:211). Sarkar (and Godfrey-Smith - see below) is inclined to abandon the latter option. Sarkar (:211) would support the weaker claim 'that DNA sequences specify protein sequences in a way that the latter do not specify the former.'

Godfrey-Smith (2000:206) suggests that the difficulties associated with using the concept of information can be addressed in two ways: use a single, specially devised concept of biological information by combining a number of distinctions about types and uses of information (Smith's choice), or take the approach that 'semantic and informational concepts have come to serve a number of distinct theoretical roles in biology'. Each role can then be assessed and the limits of its application defined. For example, Godfrey-Smith (:206) would limit the concept of coding to the explanation of protein synthesis alone and not expand it to genes encoding the structure of whole organisms.

Where does this discussion leave us? It indicates the complexity of the issues involved in applying information concepts to biology. There are differences of opinion as to the implications of the scientific results, as well as disputes about the applicability and reach of the information concepts. Clarification of the informational concepts is also required: What *type* of information are you talking about? Information as a quantity or as a carrier of meaning? What is the communication model that is being used? What do you understand by the concept of signification?

The development of a common language when talking about information concepts used in biology such as, meaning, intention and communication, is not trivial at all. Yes, we have seen that a case can be made for semantic information having explanatory relevance in biology, but just what that relevance is, is open to many different interpretations.

We have examined some of the complexities of using the concept of information in two scientific contexts (physics and evolutionary biology). The complexity increases immeasureably when we move on to the interface between science and theology. We now spell out some of the underlying issues within the framework of myths, models and metaphors.

5.2.3 Myths, models and metaphors

5.2.3.1 The roles of myths, models and metaphors in religion and science

The representation and conceptualisation issues mentioned in the introductory section, 5.2.1, are addressed by Mary Hesse (1998:120-135) in terms of a discussion of the roles of myths, models and metaphors in religion and science[46].

The question of what is religion is a very complex one. Hesse (1998:128) says that 'almost every recorded society has had a socially established system of myths, beliefs, values, social rituals and practices, usually symbolic, using heightened "poetic" forms of language, often calling on some extra-natural reality, God or gods'. Hesse (:128) stresses that these systems have important social functions such as 'creating coherence within groups', and serving as 'interpretations for every individual of their place in the world, both natural and supernatural.' At first glance, religion thus has characteristics that seem to be the antithesis of those of science, particularly the assumption of an extra-natural reality and the language of myth and symbolism that has to be used to talk about it. Hesse (:128) contends that as soon as religion tries to speak in the same terms as science, it loses its character and function as religion. The accusation against

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[46] Ian Barbour has also addressed these issues in his book: *Myths, Models, and Paradigms*, published in 1974.

religious assertions has been that they are merely 'mythical', where myth is misunderstood as being just a false story. To Hesse (:129), the 'metaphorical and mythical language of religion is perhaps nowadays the most intractable stumbling block in the confrontation between science and religion'.

Paradoxically, this very stumbling block can serve to bridge the gap between science and religion because, as Hesse says, '*science also has its myths* and is pervaded by metaphorical language' [Hesse's italics] (:129). According to McGrath (1998:179), the language of modern science is permeated with metaphors. In fact, in recent writings on cosmology, a new God has been suggested, who is 'essentially the structure of the laws of nature itself, conceived as universal and eternal, independent of human knowledge, and encompassing all possible knowledge' (Hesse 1998:123). Paul Davies talks of the '*Mind of God*' in his book with the same title. This structure of the laws is the new God created by science that allows discussion of the problems of the universe that have always been religion's domain, such as what is the significance of its orderliness and whether it was designed or not (:123). Hesse (:124) makes the point that certain scientists are more hesitant about the claims they make since some of these claims are based on extrapolation of physics beyond what we can test, as for example, what happened in the first few micro-seconds of time. In addition, Hesse (:125) asks why science should be seen as the basis for ultimate understanding when:

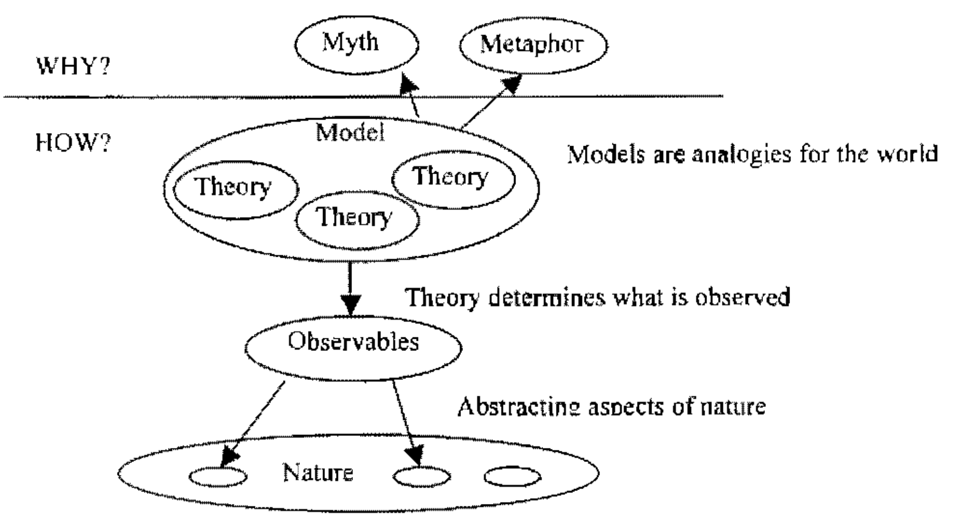
> our most fundamental theories are never totally reliable and always subject to evolutionary change? Why are such temporary imaginative models of the world important for anything else than their function in natural science itself, which is to help us organise and make use of the low-level laws that we find solidly based in experiment? That function of science does not in any sense justify grand metaphysical claims for theories.

Although this is an instrumentalist view of science, it rings true! Hesse (1998:125) also examines 'quasi-metaphysical' claims made about evolutionary biology. The theory of evolution has been used to support both the existence and non-existence of purpose in nature. Evolution has been seen as revealing an underlying purposive principle.

Hesse's point is that:

> theories taken beyond what is warranted by the experimental basis themselves take on the social functions of myth, and can be used to wield power. Like religions, these theories require metaphorical rather than literal language in order to express the *unobservable*. They are always interpretations of the observable in terms of some model of nature carrying its own metaphysical overtones. Think of Aristotle's closed world of turning spheres, with the Earth at the privileged centre, which had such influential intellectual and political effects in the geocentric disputes of the sixteenth and seventeenth centuries. World models at the current frontiers of physics and cosmology are not different in principle: they fit the data into a simplified narrative, stretching the ordinary use of language to suggest possible further developments...
>
> (Hesse, 1998:129)

We can start building a diagram to assist in understanding all these concepts.

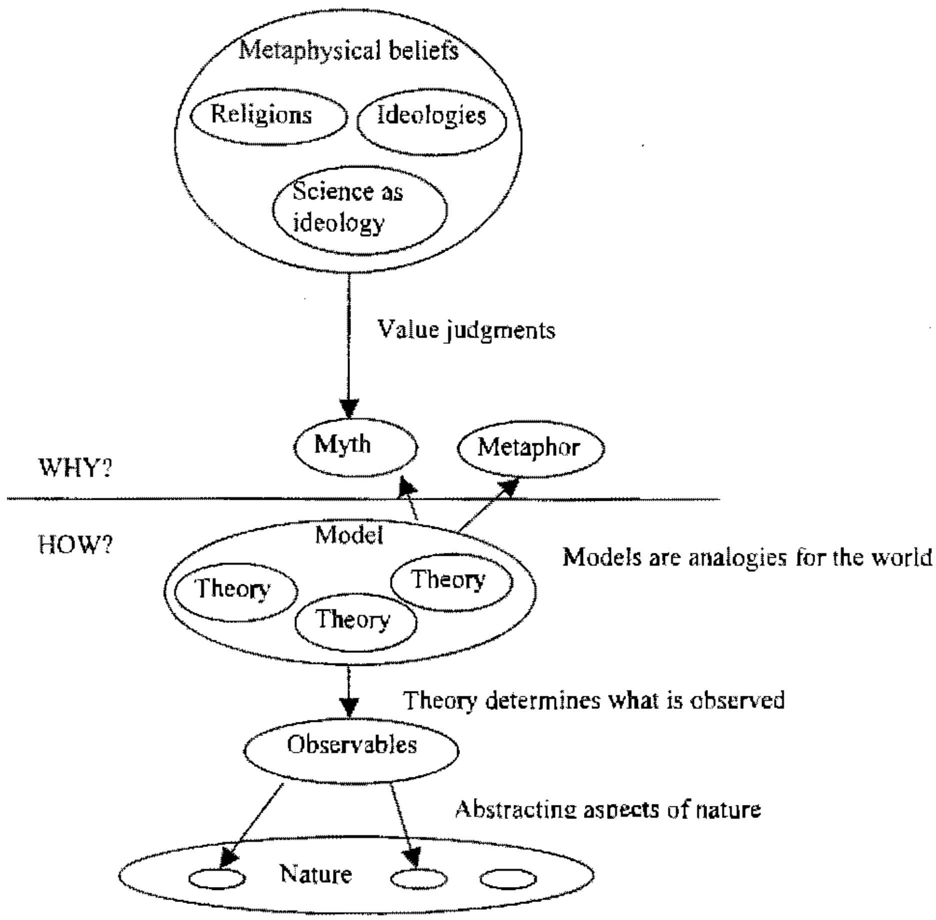


As indicated in the diagram, models and theories can take on metaphysical overtones. Hesse (:133) states that 'scientific models are analogous, not identical, with the observable world, but they cannot claim to capture the "essence" of reality'. This is indicated in the diagram by the fact that what is observed is just a fraction of reality.

In our day, the new metaphors of science, such as physical fields and information processing rather than a Newtonian mechanical view, can become myths if, as Hesse (1998:130) says, they are 'presented publicly as definitive answers to metaphysical and moral questions'. Hesse (:130) believes that:

> the correct religious response to these new myths is not ... to treat them as potential opponents of religion in their own terms, for example to announce that the mind and/or soul are nothing but organic information systems ... rather recognise that such metaphysical interpretations share some of the mythical functions of religion, and have to be judged accordingly. There are good and bad myths, and the decisions between them must depend on grounds of value and meaning which are out of reach of science itself.

The grounds of value and meaning cannot be detached from 'some kind of metaphysical belief about human nature and the world, which religions and ideologies in general have always provided' (:131). Science can also be used to build metaphysical belief systems about the world, hence becoming an ideology. We can now add these entities to our diagram on the next page.



We will now focus on the central role that metaphors play in our attempts to understand the world.

5.2.3.2 Metaphors

5.2.3.2.a What is a metaphor?

The simple answer is that a metaphor is a figure of speech. The example that has been most frequently used is: 'man is a wolf'. There are many definitions of metaphors. Harriet Crabtree (1991:12) ascribes this to the impression she has that 'metaphor currently seems to be the leading candidate for the naming of almost every symbolic structure in theology'. The definitions range from the extremes of 'metaphor as a sort of elliptical simile ("this is like that" with the "like" knocked out) to metaphor as a tensive conflation or juxtaposition of two words or sets of terminology in such a way that an entirely new piece of knowledge is produced in the mind that is obliged to hold together the improbable partners'. Crabtree (:11) follows Soskice in stressing the verbal or written aspect of a metaphor since a metaphor is a figure of speech, hence her definition: 'I use the term "metaphor" to refer to instances of writing or speaking about one area in terms commonly described to another.' Soskice's formulation is: 'metaphor is that figure of speech whereby we speak about one thing in terms which are seen to be suggestive of another' (Soskice 1985:15).

5.2.3.2.b Theories of metaphor

Soskice (1985:24-53) grouped theories of metaphor according to their visions of what metaphors achieve. She created three groups, namely (:24):

- *substitution theories* - 'those that see metaphor as a decorative way of saying what could be said literally'
- *emotive theories* - 'those that see metaphor as original not in what it says but in the affective impact it has'
- *incremental theories* - 'those that see metaphor as a unique cognitive vehicle enabling one to say things that can be said in no other way'.

Max Black talks of a 'comparison theory' as a special case of the substitution theory, in which the view is that 'the metaphorical statement might be replaced by an equivalent literal *comparison*' (Soskice 1985:26). There is common agreement today that this view of metaphor fails to do justice to the impact of metaphors. Metaphors do more than just compare 'two antecendently similar entities, but enables one to see similarities in what previously had been regarded as dissimilars' (:26).

The emotive theory of metaphor denies that metaphor has any cognitive content and assigns an affective impact to it, an extra emotive content (:26-27). Thus the metaphor 'a sharp wind' has no meaningful content, since a wind cannot be sharp, but the emotive import (e.g. fear of sharp objects) of the adjective 'sharp' is enhanced (:26). The denial of cognitive content is problematic since there must be some cognitive features to cause the emotive response.

Finally, we get to incremental theories that hold the view that 'what is said by the metaphor can be expressed adequately in no other way, that the combination of parts in a metaphor can produce new and unique agents of meaning' (Soskice 1985:31). There are many theories of metaphor that try to explain just how this new meaning is produced. A view that underlies many other theories is the 'intuitionist' theory' of metaphor that the metaphor 'involves a complete transformation, a destruction of the standard senses of the terms', and the 'unique significance of metaphor is the product of an intuitive act which follows on this destruction of literal meanings' (:31). Soskice (:31) points out that calling something 'an act of intuition' does not explain anything and that a complete destruction of the literal meanings would lead to the possibility of any reading of a metaphor being acceptable, thus rendering it meaningless. There must be some constraints or guidance being placed on the interpretation of the metaphor by the literal meanings of the terms used.

Formalist theories that discount the non-linguistic setting, such as the context and the speaker's intention, are fundamentally limited (Soskice 1985:35,36). Soskice's position is that 'A metaphor is only a metaphor because someone, speaker or hearer and ideally both, regards it as such' (:36). Her objections are against the thesis that metaphor is a matter of conflict of word meaning arising within the 'meaning-structure' of language itself, thereby excluding the pragmatic factors of context and speaker's intention (:38).

Max Black's interaction theory of metaphor addresses some of these concerns. Black's work builds on the work of I A Richards who highlighted the principle of metaphor as being the use of 'two thoughts of different things active together and supported by a single word, or phrase, whose meaning is a resultant of their interaction' (as quoted in Soskice 1985:39). The two thoughts are called the 'tenor' of the metaphor, or the underlying subject, and the 'vehicle', which is the mode in which it is expressed. Black's interpretation of this thinking was that the new context, the whole sentence, which he called a frame, imposes 'extension of meaning' on the words used metaphorically, the 'focus' (:39). In order to explain how this extension or change of meaning is brought about, Black developed his interaction theory (:40). The *meaning* that is being referred to here is not just word meaning, but meaning for the speaker and the hearer (:40).

In Black's earlier view of interaction, the basic idea is that 'a metaphor has two distinct subjects, a principal and a subsidiary one, and that the distinctive cognitive content of the metaphor is the consequence of an interaction between these two subjects, or, more properly, between the two systems of implication to which these subjects give rise' (Soskice 1985:40). Thus in the example of 'man is a wolf', the principal subject, man, is seen in a new light, due to the fact that it is being seen in terms of the subsidiary subject, the wolf. Black suggests that a kind of 'filtering' or 'screening' is happening, where we see some features and obscure others as when we look through a glass filter with certain areas blacked-out (:40). The metaphor thus creates the similarity by obscuring the dissimilarities, and hence is more that just a one-to-one comparison of antecendently existing similarities (as in a simile).

The principal and the subsidiary subjects each have their own 'systems' of 'associated commonplaces'; the metaphor relies on both the speaker and the hearer sharing some assumptions about the nature of wolves and men. Black makes it clear that the effectiveness of the metaphor does not depend on how accurate these assumptions are, but relies only on the shared nature of these assumptions. The interaction between the two subjects of the metaphor is therefore actually an interaction between the two systems of associated commonplaces in such a way as to produce a 'new, informative and irreplaceable unit of meaning' (Soskice 1985:41). Black points out that in this interaction both subjects of the metaphor are altered; the wolf seems more human after having been used in the metaphor.

Soskice (1985:41-43) discusses some criticisms of Black's theory, in particular the critique against the notion of 'filtering'. One filters out what was there in the first place, which conflicts with the idea of actually creating similarities. According to Soskice (:43), the root cause of the failure of Black's theory is his insistence that each metaphor has two distinct subjects. The issue is that a '"two subjects" position invariably lapses into a comparison theory and ceases to merit the title "interactive"' (:43).

Soskice (1985:44) develops an 'interanimation' theory of metaphor, based on Richards' work, with the objective of showing how 'metaphors can be cognitively unique, that is, how without being mere comparison they can give us "two ideas for one"'. Richards's view is that the senses of an author's words are 'resultants which we arrive at only through the interplay of the interpretive possibilities of the whole utterance', what he called the complete 'interanimation of words' (as quoted in Soskice 1985:44-45). Meanings are therefore things determined by 'complete utterances and surrounding contexts, and not by the individual words in isolation'. Therefore it is not the case that some of the words in a sentence are used metaphorically, but that 'metaphor is the consequence of the interanimation of words in the complete utterance' (:45). Richards contends that:

> when we use a metaphor we have two thoughts of different things active together and supported by a single word or phrase, whose meaning is a resultant of their interaction.
>
> (as quoted by Soskice 1985:45)

So, instead of two subjects being present as in Black's theory, we have two thoughts, and metaphor as an intercourse of thoughts. The interanimation of words is explained via the distinction between the tenor, or underlying subject, of the metaphor and the vehicle that presents it. Richards gives the following quotation:

> A stubborn and unconquerable flame
> Creeps in his veins and drinks the streams of life
>
> (as quoted by Soskice 1985:45)

Here the 'tenor' is the idea of the fever that the man has and the 'vehicle' that presents it is the description of the flame. The fever is never explicitly mentioned and therefore the A is B formulation, where the focus is on words not followed; here we have thoughts that are active together. Soskice (1985:46) sees the advantage of Richards's formulation as allowing 'us to distinguish between the tenor and the vehicle of the metaphor without suggesting that the metaphor has two subjects'. In the metaphor above, the only subject is the fever. In addition, Richards's tenor/vehicle distinction leaves room for 'subsidiary vehicles' as in the quotation above, where the description of the flame is modified by language normally used of a beast of prey.

To Soskice (1985:47), the advantage of Richards's account is that the focus is on words and the interanimation of words, whereas Black moves away from words to things, to subjects interacting. Soskice (:47) says that 'it is only by seeing that a metaphor has one true subject which tenor and vehicle conjointly predict and illumine that a full, interactive, or interanimative, theory is possible'. The full meaning of the metaphor results from the 'complete unit of tenor and vehicle' and 'the metaphor and its meaning (it is artificial to separate them) are the unique product of the whole' (:48). To ask: 'What is X the metaphor for?' is to try to separate what cannot be separated, tenor and vehicle co-operate. The excellence of a metaphor is that the subject is accessible only through the metaphor and a metaphor is genuinely creative when it embodies new insight (:48).

Soskice's definition of metaphor, namely, 'speaking about one thing in terms which are seen to be suggestive of another', can now be fleshed out (1985:15, 49). It contains elements of metaphor as a linguistic phenomenon, and the fact that two intertwined elements, namely the tenor and the vehicle, are present. The view of metaphor that Soskice (:49) wants to develop is that 'metaphor is a form of language use with a unity of subject-matter and which draws on two (or more) sets of associations, and does so, characteristically, by involving the consideration of a model or models'. Each metaphor involves 'at least two networks of associations', but these networks are 'not necessarily generated by two distinct subjects of a metaphor ... but can also be networks surrounding particular *terms* of a metaphor' [author's italics](:49-50). This allows the theory to be used with metaphors such as 'he examined his tattered scruples', where two subjects are not present, but there are interanimations between the associations of 'tattered' and those of 'scruples' (:50).

In order to distinguish between just any combinations of terms and metaphorical combinations, Soskice (1985:50), suggests that 'at a secondary level metaphorical construal is characterised by its reliance on an underlying model, or even on a number of models, and that metaphor and model are indeed, as Black has suggested, closely linked'. The models will not always be explicit, resulting in a freedom of interpretation, and therefore more than one model may form part of the associative network of a term. Soskice (:50) considers the 'associative network of a term as its placement in a semantic field where the "value" of the term is fixed not simply by the terms for which it might be exchanged, ... but also by the entities of which the term would customarily be predicated'. Even in the case of adjectival metaphors such as 'tattered scruples', a latent model arises, for 'tattered' suggests a thing that could normally be called tattered, such as clothing.

The linkage between model and metaphor is then: 'when we use a model we regard one thing or state of affairs in terms of another, and when we use a metaphor we speak of one thing or state of affairs in language suggestive of another'[47] (:50-51). The construal of an odd conjunction of terms as a metaphor depends on the ability of the reader to 'see it as suggesting a model or models which enable him to go on extending the significance of what he has read or heard' (:51).

We will now end off or discussion of the theory of metaphor by looking at it from more 'embodied' points of view, such as neuropsychology and cognitive linguistics.

5.2.3.2.c 'Embodied' models of metaphor

Danesi (1989:79), writing about neuropsychological research into the neurological programming of figurative language, puts forward a neurological model of metaphor. The model allows the location of the neurological co-ordinates of those features that distinguish between a metaphor and propositional speech acts. The features that distinguish between them are (:79):

- 'Metaphors make possible the interpretation and formulation of non-physical reality (concepts, beliefs, opinions, etc.) in terms of sensorial analogues.
- Metaphors form a lexical bridge, so to speak, between iconic (imagistic) and symbolic (propositional) thought'.

Danesi (:80) refers to the first feature as the 'sense-implication mechanism' and to the second as the 'iconicity mechanism'. Danesi (:80) explains:

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[47] We discuss the link between model and metaphor more fully in the next section - Subsection 5.2.3.2.4: *Links between metaphors and models.*

The sense-implication mechanism refers to the fact that the *vehicle* of a metaphor (=the part that makes a comment on the subject, or *topic* of the metaphor) implicates a sense modality in its content structure (=the so-called *ground* of a metaphor). The iconicity mechanism refers to the fact that novel metaphors normally elicit an image, or iconic *Gestalt*, of the content-structure.

Danesi (:80) uses the example 'John is a gorilla' to explain these concepts. The vehicle *gorilla* 'implicates an iconic transformation of the topic *John*, whereby *John* actually appears to metamorphise into the implicated animal'. The sense-related modalities associated with the vehicle ('fierceness', etc) are transferred to the topic through 'some form of Gestalt mechanism'[48]. The activation of such cognitive mechanisms is a right hemisphere (RH) function and only when the meaning of a metaphor is assimilated and stored by the verbal left hemisphere (LH) does the cognitive role of these RH functions decrease. Danesi (:80) sees the RH as 'the primary locus for the *vehicle* of the metaphor, while the *ground*, or content-structure, involves both the RH and the LH'. Metaphors are dependent on context and, in terms of this model, the LH processes the *text* of a metaphor, while the RH processes its appropriate *context* (:81). The model 'posits a RH locus for the more "imaginative" and "creative" components of a metaphor - based on sensorial or bodily experiences - and a LH locus for the transformation of such components into abstract principles of semantic organisation' (:81). Danesi (:81) points out that this links to the thinking of Lakoff and Johnson that 'metaphors are verbal tokens of the way in which the imagination links cognitive and bodily structures'.

Liebenberg (2000:276), in the context of the science and religion dialogue, discusses the work of Lakoff and Johnson, amongst others, and stresses the importance of 'what cognitive linguistics has to say about the way in which we as embodied beings instantiate meaning - from the time that we simply "equate" affection with warmth as infants, to the time when we end up using primary, conventional and novel metaphors to structure our abstract thinking about the world'. Cognitive linguistics is a

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[48] We can ask the question: When we use information concepts in metaphors, just what are the associated sense-related modalities?

fundamental rethinking of language that takes into account the details of just how the embodied mind structures experience via neural cognition, which forms the basis for what Lakoff and Johnson call 'an embodied physical realism' (:279). As humans we cannot but instantiate meaning as embodied creatures, i.e. we cannot go directly from linguistic symbols to an objective reality without passing through a physical entity called a human brain where meaning is attributed.

In this framework metaphor plays a central role. Metaphor is not just deviant language use that obscures. This attitude is based on the assumption that metaphor is primarily a matter of linguistic expression and on the assumption that all meaning is literal, words are only true if they correspond to the way things 'really' are (Liebenberg 2000:283-284). Cognitive linguists have shown that 'metaphor is a matter of concepts - not words - and that metaphorical instantiation is a matter of thought much more than of linguistic expression' (:284). It is indeed almost impossible to talk about abstract concepts, whether in science or theology, without conceptual metaphor. The reasons that Lakoff and Johnson give are that '(a)bstract concepts have two parts: (1) an inherent, literal, non-metaphorical skeleton, which is simply not rich enough to serve as a full-fledged concept; and (2) a collection of stable, conventional metaphorical extensions that flesh out the conceptual skeleton in a variety of ways (often inconsistently with each other)' (Lakoff & Johnson 1999:128, as quoted by Liebenberg 2000:284). This collection of metaphorical extensions seems to be what Soskice calls 'networks of associations' (see earlier in this section). An example given is that of the metaphorical understanding of time as a spatial dimension, which allows the conceptualisation of what is normally called gravitational force metaphorically as curvature in space-time (:284).

We now turn to a more detailed analysis of metaphor as seen by cognitive linguistics. Metaphor, as a matter of thought, not of language, is seen 'as a conceptual (not a linguistic) mapping between a source and a target domain' (Liebenberg 2000:291). In terms of the example used earlier, 'man is a wolf', the source domain of the mapping is wolves and the target domain is man or, more precisely, the behaviour of certain men. Liebenberg (:291) mentions the example of a computer virus. Through continual usage, metaphors can structure our thoughts as well so that our thinking about these computer programs is affected by the fact that we refer to them as viruses and therefore start talking about immunisation of computers, infections spreading, etc. It then happens that *virus*, when used in the computer domain, gets additional and 'more specific attributes not in the source or in the induction schema' and an evolution of meaning occurs (:292). Fauconnier mentions blending, motivated polysemy and divergence (Liebenberg 2000:292). The concept of blending is especially pertinent in the science and theology dialogue, where attempts are made to have the two domains blend into an integrated whole (:292). Liebenberg (:292) refers to the work of Fauconnier and Turner who see blending as the process in which 'structure from two or more input mental spaces is projected to a separate "blended" space, which inherits partial structure from the inputs, and has emergent structure of its own'. In most cases, as in science and theology, it is not just two concepts, but two complex theoretical systems, each in itself a system of metaphors and blends, that are being blended or related. In Fauconnier's model, the 'initial blend is enabled by a generic space or generic structure that the two concepts are perceived to share' (:293). This is what allows one to link the two concepts. Once the blend has been created, it can actually take on a life of its own, 'enabling meaning instantiation which was not possible with reference to either of the two initial concepts in isolation' (:293).

This agrees with Soskice's formulation, as we have discussed earlier, that the full meaning of a metaphor is the unique product of the complete unit of tenor and vehicle. Soskice stresses that this aspect of 'taking on a life of its own' depends on the reader's or hearer's ability to catch the suggestion of an underlying model or models, which is actually what enables one to extend the significance of the metaphor.

As Liebenberg (2000:293-294) indicates, the blending process is what lies at the heart of attempts to relate science and theology. However, this is not unusual, it happens in our daily ordinary language use as well.

Another aspect of metaphor that is very important when trying to relate science and theology is the links between metaphors and models. We are, after all, dealing with the use of information-based metaphors, which link scientific models of information to metaphor.

5.2.3.2.d Links between metaphors and models

In the previous section we discussed Soskice's view of the linkage between metaphor and underlying model. She (1985:49-50) talks of the metaphor drawing on sets of associations by involving the consideration of a model or models that will not always be explicit. The metaphor could develop or suggest a latent model that will enable the hearer of the metaphor to extend the significance of what was said. We will now investigate how models can enable this extension of significance.

Broadly speaking, models are used to regard one thing in terms of terms of another, or to view one thing in terms of its resemblance to another object (Soskice 1985:101). The nature of this 'resemblance' can take on different forms. We will briefly discuss the different categories of models that Black, Barbour, McFague, Soskice and Yob developed.

Black distinguished between scale, analogue and theoretical models (Van Besien 1989:9). A *scale model* is a scaled-down or scaled-up model of something that is intended to be a representation with similarity of proportions. *Analogue models* can be used to understand how something works and often the medium of reproduction is changed. Examples are the use of hydraulic models for economic systems and the billiard ball model to explain the behaviour of gases. *Theoretical models* describe one thing in terms from another field of science, as for example the use of computer models for the brain. New terms (including their theory) are transferred to a new field of study.

Barbour (1974:29-30) divides scientific models into four different kinds, namely *experimental models* (which include *scale models* and *analogue models*), *mathematical models*, *logical models* and *theoretical models*. We have two groupings here: physical replicas and mental models. Experimental models are physical replicas. A physical system is built to serve as a model of another physical system. The mental models of systems are the *mathematical models*, *logical models* and *theoretical models*. Barbour focuses mainly on theoretical models which he describes as 'imaginative mental constructs invented to account for observed phenomena' (:30). These models are 'a symbolic representation of a physical system' intended 'to represent the underlying structure of the world', and used 'to develop a theory which in some sense explains the phenomenon'. Theoretical models are what is involved when we talk of the linkage between metaphor and model. When Barbour (:30) compares scientific and religious models, he uses theoretical models in the comparison.

McFague (Yob 1992:481) also prefers theoretical models instead of what she calls structural and computer models, since 'they are, in essence, metaphors, but their distinguishing feature is the stress on similarity of structure between model and modelled'. This similarity of structure cannot lie simply in the physical similarity, since in that case scale models would actually have been the best choice.

Soskice (1985:101) warns of the 'conflation of the categories of "model" and "metaphor" ', and accuses Black and Barbour of doing just that. Black's definition of a model is that it is 'a systematic analogy' (Yob 1992:481) and Barbour 'discusses models as "systematically developed metaphors", and treats the difference between the two as largely a matter of degree' (Soskice 1985:101). Soskice warns that seeing models and metaphors as both proposing analogies leads to a comparison theory of metaphor.

Soskice (:102-103) distinguishes between two main types of model, namely *homeomorphic* and *paramorphic* models. In homeomorphic models, the subject (whatever the model represents) is also its source (whatever the model is based on). In paramorphic models, the source and the subject differ (as in the billiard ball model for gases). Homeomorphic models are 'models "of" a state of affairs' (Barbour's physical replicas), whereas paramorphic models are 'models "for" a state of affairs' that do not demonstrate clear parallels, but merely 'suggest(s) candidates for similarity and give form to deliberation on unfamiliar matters' (:103).

Yob (1992:481) argues that Soskice, although recognising the dangers of conflating models and metaphors, nevertheless suggests that models and metaphors both propose analogies. Models function as comparison-makers in Soskice's analysis of the difference between homeomorphic and paramorphic models. Furthermore, if metaphorical thinking means thinking in models, as Soskice argues, 'the net result is a lapse into a comparison theory of metaphor' (:481). The crux of the matter is that what Soskice calls the 'projective conventions', which permit a model to resemble its source, are not the same for all types of model. These projective conventions permit characteristics read off the model's source to be predicated of the subject of the model (Soskice 1985:101). In the case of a scale model of a train, the projective conventions are not novel since a routine scaling operation has taken place. Goodman talks of 'routine projection' which applies familiar labels to new things but not in novel ways (Yob 1992:482). When metaphor is involved, conflict develops, since, in some way, the application of the familiar label to the new thing defies an explicit or tacit *prior* denial that this label could be applied to the new thing. Yob wants to use the terms *literal* for routine projections and *metaphorical* for non-routine projections. The categories or characteristics of a scale model are projected onto the actual object quite literally. The schematic organisation of a homeomorphic model is applied to the object in a straightforward, literal manner. The schematic organisation of a paramorphic model is applied to the object in a novel, creative way.

Just as Soskice talks of metaphors as 'speaking of one thing in terms suggestive of another, (which is not simply a matter of comparing characteristics but evokes conflict) so can we talk of models supplying a schematic organisation to a relatively unfamiliar domain to which it has previously been denied (Yob 1992:482-483). Models are then a way of seeing things in ways not yet imagined, thus evoking insight. Yob (:483) wants to label certain models *metaphorical*, since it is an appropriate extension of the domain of meaning of *metaphorical*.

Yob (1992:483) summarises her position by saying:

> genuine metaphors and many models function similarly in that they call to mind organizing schemata which are applied to new realms for novel insights. In the transfer of a network of associations, including both the literal and the figurative associations from its original setting to a new one, these metaphors and models guide the exploration of the new setting by proposing entities, structures and relationships by which it may be understood. Only under these conditions, are the labels 'metaphor' and 'model' interchangeable. However, some models do not function this way. Their organising schemata are simply

extended to a new realm by reading off correspondences without any sense of invasion or resistance. That is, genuine metaphors act as many models but not all models act metaphorically.

These distinctions are important when we try to understand where the power of a metaphor comes from. It seems that a powerful metaphor needs a 'metaphorical' underlying model that will invite and guide exploration of the new setting to which it is applied.

We have talked of models that act metaphorically. Soskice (1985:102) reminds us that the 'presentation of a model, its *linguistic* presentation, that is, can take the form of a metaphor as in the sentence, "The brain is a computer" ' [Soskice's italics]. Metaphors that propose a model in this way are called 'theory-constitutive metaphors'[49] and should be distinguished from 'metaphors which are the linguistic projections of such a model; for example, the cybernetic model of the brain [as mentioned above] ... is developed by discussion of neural "programming", "output", and feedback" '. These terms are called 'metaphorically constituted theory terms' by Soskice (:102).

We will now address the use of metaphors, starting with the basic question of the need for metaphors.

5.2.3.2.e Why are metaphors necessary?

In the preceding sections we have already touched on the value of metaphors. Let us now explore this aspect in more detail. Metaphors are a part of our interpretative frameworks. Our culture and the home language with which we have grown up teach us how to construe the world in terms of categories (Crabtree 1991:2). Our conceptual system is 'fundamentally metaphorical in nature' (Lakoff & Johnson 1980:3). The way we interpret reality is shaped by the extended metaphors or models that we use, like the metaphor of the world as a giant clockwork, or the metaphor of the world as 'a universal language' (Turbayne as quoted by Emmeche & Hoffmeyer

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[49] Soskice (1985:174) refers to 'theory-constitutive' metaphors as being Richard Boyd's terminology.

1991:27), or use information which is the current metaphor of choice for the scientific world-view (Siegfried, 2000:45).

Ortony has developed three arguments for the need for metaphors (as discussed in Woudstra 1989:50 and Van Besien 1989:7):

1. *The argument of compactness* - you can convey a series of attributes and relations in a few words.
2. *The argument of unnameability or inexpressibility* - it is often impossible to translate complex and abstract notions into everyday language. Our experiences are continuous, which makes it impossible for our word meanings to have all the distinctions required to express all the detail.
3. *The argument of vividness* - metaphors make a connection with something known from the concrete world, thus giving us the ability to visualise things.

Van Besien (1989:6-11) has studied the use of metaphors in scientific texts and he distinguishes, on the basis of their different functions, between 'pedagogical' and 'theory-constitutive' metaphors. The three arguments of Ortony support the pedagogical functions of metaphors. Although metaphors can lead to insight, there is also risk associated with the use of metaphor due to the lack of control over the receiver's interpretation. We have discussed theory-constitutive[50] metaphors that propose a model. We have also speculated that a powerful metaphor needs a 'metaphorical' underlying model that will invite and guide exploration of the new setting to which it is applied. To Soskice (1985:51), the 'close association of model and metaphor is important ... for explaining why metaphors can be so useful'.

5.2.3.2.f ***Religious metaphors***

In religious language figures of speech are 'the vessels of insight and the vehicles of cognition' (Soskice 1985:54). As we have seen in the previous section, metaphors shape our interpretation of reality. Religious metaphors 'are particularly powerful shapers because of their blend of cognitive, affective and emotional elements'

[50] As discussed in Subsection 5.2.3.2.4: *Links between metaphors and models*.

(Crabtree 1991:3). A metaphor such as 'God is our Father' evokes a whole host of emotions and images. The power of religious metaphors is strengthened by their presence in the language we use in our rituals and devotions, as in the 'Our Father' prayer for example. Religious language 'affects the lives of its users because those earthly phenomena on which it draws in speaking of divine matters receive a reflected glory and power from the object on which they are projected' (Crabtree 1991:4). As Tillich has also discussed, religious symbols connect the infinite and the finite, and in the process the finite is also glorified to some extent, which could lead to dangerous dynamics, as in if God is Father, then fatherhood is consecrated as well, which may lead to 'if God be male, the male will be god' (Crabtree 1991:4-5).

Of course we must never forget that for all their power, religious symbols are 'to a high degree the product of the human imagination' and that humans have 'structured the language in which their import is elaborated' (Crabtree 1991:5-6). This is very explicitly true in our use of scientific concepts in religious metaphors.

5.2.3.2.g ***The Good, the Bad, the Lively and the Dead***

With regard to deciding on the excellence of any particular metaphor, Soskice (1985:48) feels that a metaphor is excellent if the subject is accessible only through the metaphor and a metaphor is genuinely creative when it embodies new insight. 'It is the capacity of the lively metaphor to suggest models that enable us to "go on" which gives the clue to the richness of metaphorical description' (:51). We can also say that fecund models underlie lively metaphors. We have talked of the power of a metaphor that comes from a 'metaphorical' underlying model that will invite and guide exploration of the new setting to which it is applied[51]. Sally McFague talks of the most 'fruitful' metaphors as being those with 'sufficiently complex grids to allow for extension of thought, structural expansion, suggestion beyond immediate linkages ... It is because some metaphors have structural possibilities that ... models can develop from them, for models are dominant metaphors with comprehensive organisational potential' (as quoted in Crabtree 1991:13).

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[51] See Subsection 5.2.3.2.4: *Links between metaphors and models.*

Dead metaphors do not invoke new insight anymore because we have become used to them and their meaning is too conventional. However, some metaphors do not die, even when their novelty has worn off. Ina Loewenburg sees 'dead' metaphors as those used without any sense of their origins as metaphors. 'Novel' metaphors are new, and 'live' metaphors are neither clearly novel nor obviously dead, but are used as metaphors by some, while for others they are moribund (Crabtree 1991:13).

With regard to religious speech, Van Noppen (1992:145) says that the adequacy thereof 'is not to be assessed in empirical terms (because no testable predictions or inferences can be made), but with regard to their ability to "illuminate", i.e. their success in invoking insight in a particular situation and at a particular time'. The value of a metaphor can then be measured by 'the degree of social adhesion' to it (:145). So, if a metaphor has value to some community, they will keep it alive.

Can we have good or bad models? Soskice (1985:104) questions the 'not uncommon practice of lifting a particular model from its context in the physical sciences and transplanting it whole into theological ground, without giving sufficient account to the qualified, theoretical status that the model may have, even on its home ground'.

In terms of looking at what makes for good or bad metaphors in talking about science, Ursula Goodenough has written a relevant article, which we will now discuss.

Ursula Goodenough (2000) has made the case for the use of metaphors when trying to convey the results of science. Her view is that we are deeply anthropocentric and if we try to use scientific language to convey scientific concepts, we will lose the battle for human attention since we are used to hearing stories from our culture and religion that reaffirm our centricity. As she says: 'If the universe story is to compete with other stories for human attention, we need to offer human-friendly analogies for those who best understand scientific concepts through experiential referents' (:235). Goodenough gives the example of Brian Swimme using the metaphor 'Gravity is love' and how that resonates with some people who have been alienated from the scientific understanding of the universe. Of course, although this metaphor can help, it is also very wrong, in the sense that apart from the superficial similarity of possessing the property of attraction, there are very few other commonalities between love and gravity (:235).

So, if metaphors have a role to play, the question becomes: How should they be crafted? To Goodenough (:235), the problem is: Who is going to create these metaphors? She gives the example of the metaphor of God as intelligent designer, embedded into the sentence 'Evolution is the Work of an Intelligent Designer' (:235). In this case we not only have a metaphor, but also 'an implicit interpretation of the mechanism of evolution' (:235). This issue has been discussed here under the sections dealing with Dembski's work. The problem is that the metaphor of design leads us to think of a particular sort of design, intelligent design as practised by human designers, whereas the scientific notion of design arising out of random mutation and natural selection is counterintuitive and utterly foreign to our experience. Note how the word 'intelligence' immediately makes one think of a person. We qualify intelligence with the term 'artificial' when referring to non-embodied intelligence - e.g. computer programs with Artificial Intelligence (AI). Goodenough therefore asks: How can one communicate counterintuitive concepts? Her response is to develop two rules of thumb (:235):

- You must really understand the science and 'have the metaphor ring true with science'.
- If a metaphor is valid - if it carries some core truth about an understanding - then it should carry that core truth over to someone else.

Goodenough (:235) feels that the design metaphor 'intentionally misrepresents the science so as to make a doctrinal point'. In the case of Dembski's work, I do not quite agree with this accusation since the notion of Complex Specified Information and the whole argument about the shear improbability of complex entities arising by chance is an attempt to argue at the scientific level. We can debate the quality of the science, but the intention is at least there to make a scientific case without gross misrepresentation of the scientist's reasoning and models of evolution. What does it mean to have the 'metaphor ring true with science'? This is not an easy question to answer and Goodenough does not give any answers, just examples of bad metaphors such as feeling DNA's presence in a room or calling the sun 'generous'. Liebenberg

(2000:289, 295) talks of 'folk theories' in contrast to theories based on empirical studies. It seems that we should judge on the basis of the underlying theory and its models.

With regard to the second rule of thumb, Goodenough (:236) rightly says that scientists use metaphors all the time when communicating with each other since it is easier to convey valid understanding of the science involved in analogical language. Hence the 'messenger RNA', 'genes that hitchhike', etc. According to Goodenough (:236), 'gravity is love' works as a metaphor since it conveys the core truth of the 'inevitability, the inexorability, of gravitational attraction that many of us have best experienced in love'.

In dealing with religious metaphors, Goodenough's position is that religious metaphor differs from scientific metaphor only in the manner in which the core truth is conveyed (:238). Scientific understanding can be conveyed via the 'crisp minty snap of empirical data or by metaphorical renderings of these data', whereas the core truths of a religious tradition are 'invariably articulated in metaphor' (:238). One could ask whether the empirical data is not also always interpreted via a theory, so that 'crisp and minty' lives more in the scientist's mental model rather than being inherent in the data. Goodenough (:239) feels that we should have the freedom to work with the metaphors of our religious tradition, translating the original texts as evocatively as we can, where the originals inform and constrain.

How do we judge whether information is useful as a metaphor? We run into trouble when we use the concept of meaning information as a metaphor. The interesting issue is that information gives form to our understanding as the end-result of a process, and metaphors are also an integral part of that process, possibly at a higher level where information is integrated in some fashion (e.g. the line of thinking that a metaphor gives us two ideas for one without it being mere comparison[52]). Metaphors are carriers of information *par excellence*. Metaphors *are* information. The meaning of information is understood metaphorically. It is easier to understand the usefulness of counting information as a metaphor since there are underlying scientific models that

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[52] Please refer to Richard and Soskice's work on theory of metaphor in Subsection 5.2.3.2.2.

can be applied to extend the meaning of the metaphor. An example would be the scientific model of information involving selection amongst possibilities. Shaping information is difficult to use as a metaphor because it is not clear what scientific model is relevant. In addition, as we asked in the previous section, when we use information concepts in metaphors, just what sense-related modalities would we associate with them?

Crabtree (1991: 10) stresses the role of the visual component of our picturing of reality. The use of images in language is effective due to their pictorial nature which makes them convincing because vision is such a strong sense. Crabtree (:10) states:

> Good models in science may not have to be picturable, but picturability certainly seems important in the realm of metaphysics and religion; descriptions in this arena would appear to follow Marcus Hester's dictum[53] that at least one of the two components of a metaphor must be "image-exciting". They catch the imagination and lodge more firmly in the memory.

Information is quite difficult to picture. The best I can do is to depict streams of letters and words that float by or a semantic network picture in which one moves from concept node to concept node. Each concept is then defined by its relationships with other concepts in a network. This probably comes close to the idea that metaphors have underlying models that can supply a schematic organisation to a new domain[54]. However, Crabtree (:11) quotes C S Lewis who argues that the visual aspect can be a positive hindrance in theological thinking, just as 'toys too elaborate and realistic spoil children's play'.

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[53] See reference under Hester, M.

[54] As discussed in Subsection 5.2.3.2.4: *Links between metaphors and models.*

5.2.4 Dippel's work as an example of the use of metaphors

5.2.4.1 Introduction

In order to introduce the use of metaphor in the science and religion context or interface, we use the work of the Dutch scientist Cornelis Johannes Dippel who published many articles on the role of science and technology in society (Van Dijk 1992: 91-96). Dippel used the concept of information as a metaphor for the theological concept of revelation (:91). He made the link between information and revelation by focusing on a specific meaning of information as that which increases the order when added into a system. The increase in order is linked to a decrease in uncertainty and diminishing interpretation possibilities. This is what happens to a believer, too, when professing acceptance of God's revelation, since uncertainty is removed and order is created in the mind of the believer. Revelation contains information and makes us aware of God's pattern of ordinance which is the result of God's intentions. When we adhere to God's laws (ordinances), we introduce order into our lives. God's order is seen by Dippel as being different from our human definition of order. God's order is 'the order of freedom, unconstraint and contingency in the sense of non-uniformity' (Dippel as quoted in Van Dijk 1992:92).

Dippel has also suggested an analogy here. Just as the introduction of information into a system decreases uncertainties about the state of the system, so does the acceptance of God's revelation decrease the uncertainty of the believer and create order in the thinking of the believer.

We can use the example of a dice with six sides, numbered 1 to 6 (Van der Lubbe & Laurent 1992:86). Before we throw the dice, we, the observers, do not know which of the six sides will be up. The throw removes our uncertainty and gives us 2.58 bits of information[55]. In Dippel's analogy, we have the believer as the observer. One needs to be careful about the use of the concept of 'order'. The word 'system', as used by Dippel, does not automatically provide the picture that we are dealing with an observer as part of the system. One is inclined to think of a set of blocks being ordered when one hears the phrase 'increasing the order of a system'. The concept of

[55] (log 6)/(log 2)= 2.58

order lies in the mind of the observer. In information terms, we may use less information to describe one series of events, e.g. three rows of the dice, resulting in 1, 1, 1 or 1, 2, 3, and, whereas 1, 1, 1 would have a lower information content than 1, 2, 3 where information is used as a measure of complexity. In terms of denseness of information, both sequences could be judged by an observer to be equally ordered.

Although Dippel acknowledges that the believer must profess acceptance, the following step, which is phrased as creating order in the thinking of the believer, can leave the impression of a mechanical ordering operation: God rearranging our 'jumbled' thoughts? This kind of picture denies the active role of the receiver of the information.

Van der Lubbe and Laurent (1992:87) have criticised Dippel for putting forward a process of communication that is characterised by 'one-way traffic from God to man and world'. They emphasise the two-way aspects of communication as well as the role of the receiver (1992:87). The receiver determines what information is and information is always relative to the receiver. Communication from the receiver to the sender must also be considered. Therefore they see the relation between God and the world as dynamic, two-way communication[56].

These criticisms are acknowledged, but Dippel does also talk of the problem that we associate obedience to God's information with necessity and lack of freedom (Van Dijk 1992:93). Freedom is only possible on the basis of obedience, for example, we can decide to walk somewhere, but our limbs must obey the commands. '"Possibility" responds to information, from which freedom develops' (:93). Dippel connects this idea of freedom with that of Karl Barth, who said that a person is only free if, in agreement with God's freedom, he/she makes a choice for it[57] (:93). In information terms, this idea translates into obeying divine information by accepting it, by letting

[56] See also the discussion on Van der Lubbe and Laurent's view of God as the source of information in Section 5.3: *Enriching our concept of God*.

[57] *'Frei wird und ist er (der Mensch) in dem er sich selbst in Übereinstemmung mit der Freiheit Gottes wählt, entscheidet und entschliesst'* (Man becomes free and is free, if he himself is in agreement with God's freedom, chooses it, decides for it and accepts it). (Karl Barth in (1953) *Das Geschenk der Freiheit*, Theologische Studien, 39, 9, as quoted by Van Dijk 1992:93).

oneself 'be polarised by the humble field of the information of God's Word' (:93). This combination of scientific concepts is, to my mind, not very helpful. How can a field be humble? It can have strength and directionality, but not humility. How can information produce a field? This metaphorical language does evoke a reaction, but the visual element, which is so powerful, as in the example we gave earlier of 'examining tattered scruples', is missing. We can envisage a tattered garment, but who can easily envisage a field? My guess is that the attempt is to indicate some kind of interaction at a distance between God and the believer, what would normally be called the work of the Holy Spirit. The underlying model is that of an electro-magnetic field. Van der Lubbe and Laurent (1992:87) use the formulation of 'an offer of possibilities by God', which does not carry all of the above scientific baggage.

Dippel goes further to fan out the concept 'information' in a scale of significations in order to use it to bridge the gap between science and theology (Van Dijk 1992: 92). God, the creator, is the 'Informer' of matter and God's reality is the Word. Informed creation owes its existence to and is in information which we call the Word of God and God is the keeper of all information (:92). Here we have what we have called *shaping information*, where information is used to describe the action of giving form to something. This world obeys God's information (the laws of nature) and will disintegrate if God stops providing this information. The laws that we can discover via scientific methods are only what Dippel calls the 'outside of the building of creation', since we cannot see the 'secret of creation' via scientific methods (:92-93). Presumably this is why revelation is needed.

Dippel talks of *unique* versus *public* information (Van Dijk 1992:94). Public information is that which you filter or decode out of the disordered flow of experience through the application of common sense. Unique information is contained in the unique experiences between God and humankind, as, for example, in the stories of the Bible, and it is decoded through faith with God participating in the decoding process through the 'self-activation' of the Holy Spirit (:94). Normally, Christians would talk about looking at the world through the lens of faith. Although religious information, as in the Bible stories, can be transferred, Dippel contends that unique information cannot be transferred without the intervention of God. God, through the Word and the Holy Spirit, creates 'canals' in our mind so that we can receive and decode unique information (:94). Dippel linked this to the concept that information forms its own channels. The particular example used is that of the evolving cell, in which the receipt of information results in changes that can be attributed to the information itself, rather than to the cell. Van Dijk makes the connection here to Karl Barth's proposition that 'God's Word constructs its own channels and forms its own points of contact' (:95). All of this ties up with the concept of information being 'active', which is Peacocke's formulation as well.[58]

With the concepts of public and unique information, the gap or difference between science and theology has been reinstated again. As van Dijk (1992:95) says: 'Unique information leads to faith and not to natural science. The gap between particularity and generality cannot be bridged'. This gap might be seen as being one created by the different *methods* followed to decode the information. The question does remain whether Dippel actually explains anything by calling faith an experience of unique information. Unique information seems to be just a label for the participation of God in the decoding process.

Van Dijk (1992:96) thinks that Dippel's work has an impact on the fundamental issues about the nature of God and the nature of reality, and in the area of the religious language, where using the term 'information' instead of 'revelation' has certain advantages.

5.2.4.2 Information, the nature of God and the nature of reality

Van Dijk's (1992:96) interpretation is that Dippel shows:

> that we cannot think materially enough about God and at the same time not spiritually enough either. Perhaps this is why the term 'information' as a third concept, alongside matter and spirit, is so suitable for bridging the gap between experience and revelation, or between unique and public information. It points to a fundamental structure of reality, which presupposes matter and energy, but at the same time *transcends* them [my italics].

[58] See the discussion in Subsection 5.6.5: *Active information*.

'Thinking materially' about God here is probably meant in the sense that God created and sustains the world through information inputs, and 'thinking spiritually' is possibly used in the sense of assisting the decoding of unique experiences (revelation) into unique information. Information is thus a bridging concept in the sense of showing us the two faces of reality, matter (=energy since matter is energy ...) and information, as well as the two aspects of God, namely a God who acts on the material world through information in the form of laws and also 'acts' spiritually through (possibly) the fundamental informational nature of reality, opening our eyes to see a different reality that we call the experiences of faith.

The question of how information *transcends* the concepts of matter and energy is a difficult one. One way of thinking about it in the context of information is that it does come back to the issue of meaning 'happening' in the mind of the receiver, i.e. information is only information if it understood by somebody, some conscious entity. This takes us back to the mind/matter duality problem as well as the problem of consciousness. David Chalmers has gone so far as to develop a theory of consciousness that posits the existence of information as a new fundamental property [59](Horgan 1999:242).

Another approach is to how the way we think and talk about the world has an impact on the mind/matter duality problem. Cognitive linguistics, which takes embodiment as being the foundation of human understanding, is important here, since it 'can provide us with a means of philosophising which is not dominated by a dualism between the mind and world (a view which alienates us from our bodily existence in the world), but perhaps is more in line with the way in which we as a species with a common phylogenetic past normally think and interact with the world' (Liebenberg 2000:286). We, as embodied beings, create our sense of reality.

[59] For further discussion of this work by Chalmers, refer to Subsection 5.6.7: *The interconnectedness of it all – recent developments in our understanding of reality*.

If we examine information as a fundamental entity alongside energy and matter, then we must decide on what role the observer plays in creating reality by observing, as is being debated by quantum mechanical theorists.

Understanding reality is not easy and using 'information' as a third concept does not make it any easier, but it does direct the quest for understanding along different routes, with a more reflexive tone, where the entity trying to do the understanding is central.

A key problem is, as Van Dijk (1992:96) rightly suggests, that we need to be careful to avoid overloading the concept of information with so many meanings that it actually loses all meaning. As outlined above in our discussion of Dippel, his use of the word 'information' ranges from applying it to God's creativity in informing matter, to the laws of nature, to faith as the experience of unique information, and to the material and humankind-creating Word (:95-96). The 'bridging' concept may connect to so many webs of meaning that one would become totally lost in trying to cross the chasm by using it!

5.2.4.3 Is using 'information' better than using 'revelation'?

According to Van Dijk (1992:96), the term 'information' has the:

> fundamental advantage of not having the mythological, miraculous, and authoritarian undertone that the word 'revelation' brings to mind for many persons. The use of the term 'information' for publicly available experience as well as for religious experience prevents the mind from imagining that 'unique information' consists of all kinds of petty facts and details. And it reminds us that a religious person does not know more and other things than an unbeliever, but the same things in a different manner, under a different light, or from another perspective.

I would agree that revelation has definite associations, which might be positive or negative, depending on one's beliefs and background. The concept of information carries its own baggage too. Information is a difficult concept to understand and has many different meanings. In the discussion above we have run through the *counting, meaning* and *shaping* approaches to information. What we have called here different "meanings" are actually derived from the fact that we have here three different networks of associations and three different models for information[60]. When Dippel talks of revelation as information we have two underlying models at play: information as that which reduces uncertainty, information as counting information with its model of a communications channel between a sender and a receiver; and information as the imparting of knowledge, information as meaning information with the model of human communication. As Emmeche and Hoffmeyer (1991:3) indicated, we have here information as an objective quantity, measured in bits and bytes, and information as a subjective category, where information is always information *for* someone, which cannot be quantified into bits and bytes[61]. This brings in the subjective dimension which does resonate with the position that revelation needs to be accepted in the subject, but the uneasy clash with the quantitative connotation of the reduction of uncertainty remains. Can one quantify how uncertain a person is about God? It seems to me that the network of associations with 'objective' information can easily dominate. Indeed, at first glance, when people speak of information it does bring with it the impression of objectivity, of data in context, data that can be transmitted around the world to a TV or computer, the connection to the 'messy' world of language and interpretation is not all that evident.

A subtle issue is that if we use a metaphor (e.g. 'information' for 'revelation'), we need to be aware that the metaphor can affect what we see and how we interpret it. In fact, metaphors can govern or direct the way we think about issues. This was shown by Lakoff and Johnson (1980) in their book *Metaphors we live by*. Vico, a proponent of a 'strong' metaphor theory, recognised that minds are formed by language and not language by minds[62] (Soskice 1984:76). If we analyse the way that Dippel talks about information and related issues, some of the underlying assumptions or models come out. When Dippel talks of order being created in the thinking of the believer who

[60] Part of Soskice's understanding of a metaphor is that the metaphor draws on two (or more) networks of associations by involving the consideration of models (Soskice1985:49).

[61] See Section 2.3: *Biological roots of information.*

[62] James Edie's formulation.

accepts God's revelation, we are dealing with the folk metaphor of thoughts being objects that can be ordered and thought as being object manipulation (Liebenberg 2000:295). Dippel talks of 'canals' being created in our minds by God, Word and Spirit, for us to understand the unique experiences of faith (Van Dijk 1992:94). We have also mentioned the connection made to Barth's proposition that Gods' Word constructs its own channels. The metaphoric understanding of the mind as a channel, or as 'something which is reachable by "some channel of revelation" ' has also been used by George Ellis (Liebenberg 2000:297). As quoted in this section, Van Dijk (1992:96) talks of a religious person knowing the same things from another perspective than a non-religious person. Here the link is to the metaphor of revelation or understanding being *seeing what is hidden* (Liebenberg 2000:297). Liebenberg's contention is that here we have a folk view of the mind that is not based on empirical study, but is dependent on the dualism between mind and matter (:297). When we talk of thoughts as objects, we are using the conduit metaphor for communication, where we can pass these objects along the canal or channel into the mind/brain (:297). This 'folk theory of communication does not hold in the face of contemporary evidence for the way we instantiate meaning as embodied entities' (:297).

When we examine Dippel's linkage to the concept that information forms its own channels (van Dijk 1992:95), things get really interesting. Take Dippel's example of the evolving cell, in which the receipt of information results in changes that can be attributed to the information itself, rather than to the cell. Here we have the possibility of a radical acceptance of embodied understanding, realised in changes to the cell. There is no separation between data and structure. Lakoff and Johnson talk of three levels of embodiment of concepts, namely *neural embodiment*, the neural-level structures that characterise concepts and cognitive operations, the *phenomenological level*, which is all that we can be aware of – our bodies, our mental states, our environment – and the *cognitive unconscious*, which is all the mental operations that structure and make possible conscious experience, the understanding of language (Liebenberg 2000:280). So when the receipt of information results in changes to the cell, in this case the brain, we are talking of the neural embodiment of concepts. With regard to an underlying model, we should stress the two-way interaction aspect. The brain has neural structures with existing interconnections. If we want to think of information forming its own channels, then we should rather talk in neural terms of existing connections being strengthened (information as structure?). Thus we get back to an active interpretation role being played by the receiver, even at this level. The brain would filter the sensations coming in, in terms of existing structures. At the cognitive unconscious level, the mind/brain would also be active, structuring the experience into language-based understanding (information as meaning). Perhaps we can say that the mind/brain forms 'its own channels' in response to incoming sense data since the process is not simply a matter of information on its own forming its own channels.

We now re-examine Dippel's concept of unique information, where God participates in the extraction of the unique experiences contained in the Bible through the 'self-activation of His Spirit' as Van Dijk (:94) has formulated it. It seems tempting simply to formulate it as public information + God's action. The believer has another perspective, which, according to Dippel, God has played a role in developing. We have seen that our embodiment plays an active role in shaping the understanding of this information. Dippel does talk of our freedom to obey God's information by accepting it. This acceptance role is not passive, but active and interpretive. The question remains: What is God's role in this? Does this metaphor of information as revelation help?

5.2.4.4 *Summary of the evaluation of information as metaphor for revelation*

Cognitive linguistics talks of a *conceptual blend*, a *conceptual mapping* between the complex systems metaphors and blends of the source and the target domain. Lakoff and Johnson have shown that metaphors use a base domain, or a familiar domain, to allow us to be able to interpret and understand a new domain. Once we have understood that the concept of information has many meanings, it then becomes problematic to use it as a metaphor since it is difficult to decide which base domain the metaphor will be carrying in with it. This depends on the understanding that the hearer or listener has of the concept *information*. How familiar are we with the base domain of information? We are mapping from a complex domain consisting of counting, meaning and shaping information with various underlying metaphors and models of communication as well. Yes, new meaning does become instantiated, and it is very pliable and open-ended. The mystery of revelation is not reduced, but enhanced, and this is a good result if you are not seeking explanation, which is probably an impossible task in any case.

As we previously have discussed[63], metaphors are judged by their ability to 'embody new insight', to be 'lively' and 'to illuminate'. Information is lively enough when used metaphorically, if complexity is what you mean by liveliness. In the case of revelation, this complexity is appropriate. The new insight can also not be dissected without losing impact, although it seems that one can extend the insight evoked through the interactions of the web of meanings of the subjects of the metaphor. We have shown that the three meanings of information do provide these complex webs of meaning, and also asked whether they are too complex. When scientific concepts are involved, we have the problem of 'lifting a particular model from its context in the physical sciences and transplanting it whole into theological ground, without giving sufficient account to the qualified, theoretical status that the model may have, even on its home ground' (Soskice 1985:104). We have also discussed Ursula Goodenough's two rules of thumb (Goodenough 2000:235):

- You must really understand the science and 'have the metaphor ring true with science'
- If a metaphor is valid - if it carries some core truth about an understanding - then it should carry that core truth over to someone else.

Puddefoot (1992, 1996) has formulated the outlines of a model that ties together all the different meanings of information that we have discussed here. His interpretation is that counting information is the basic raw input that must give form to our minds, thus informing us in the sense of shaping information, in order to convey information (meaning) to us (Puddefoot 1992:15, Puddefoot 1996:312). Puddefoot has also discussed the role of God in revelation. His contention is that minds are necessary but not sufficient for the perception of meaning, 'what opens our eyes is the uncreated creative light of God's Word' and meaning is only there for 'minds engaged with the world in the process of becoming personal' (Puddefoot 1992:15). If we accept this contention, then counting information is the only meaning of information that is clearly understood by science. The role that this aspect of information plays in the

[63] See Subsection 5.2.4.2.6: *The Good, the Bad, the Lively and the Dead.*

metaphorical use of information is limited. To me, the other aspects dominate – the shaping and meaning information. In both cases the science is problematic - do we understand shaping information? We have shown that meaning and metaphor are also closely intertwined and that cognitive linguistics is only scratching the surface of the complexities. In addition, our understanding of consciousness, the 'last frontier of science', is also involved. So meaning information is not well understood. We cannot answer the question: Does the metaphor ring true with science? In fact, almost any interpretation will ring true with some tentative scientific model that has been postulated. Is the metaphor valid, does it carry some core truth and provide some understanding? If one believes in revelation and that God plays a role in 'opening our eyes', then yes, the use of information, especially, meaning information, does carry with it the mystery of how embodied organisms make sense of information. The implicit model that one does need to assume is that God plays a role in making information make sense, what Dippel called 'unique information'. This model is not generally amenable to scientific study since human experience, consciousness, etc. all come into play and these are not easily accessible to the mostly reductionistic tools of science.

Finally, we have to realise that we are in 'mythical' territory here. As we have discussed earlier[64], the new metaphors of science such as information processing can become myths if, as Hesse (1998:130) says, they are 'presented publicly as definitive answers to metaphysical and moral questions'. In Dippel's work do we have a religious myth appropriating a scientific myth? Or is this a religious person using a scientific myth to bolster a religious myth? We are dealing with metaphysical interpretations here. Hesse (:130) believes that 'there are good and bad myths, and the decisions between them must depend on grounds of value and meaning which are out of reach of science itself.'

Before we proceed with an example of the use of information concepts in theology that has a wider scope than Dippel's work, we discuss some of the general problems in relating science and religion.

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[64] See Section 5.2.4:*Myths, models and metaphors.*

5.2.5 Problems in relating science and religion

In trying to relate science and religion, Hesse (1998:131) contends that the sociological study of religion can act as a bridge between them. The approaches used in studying religions from the sociological perspective have been used to study science as a social phenomenon and have led to the understanding that science is also a social institution, with all that that implies in terms of social relations, such as power and authority relations (:132).

Hesse (:133) goes on to draw parallels between the way in which metaphysical models work in both scientific and religious discourse.

Scientific models are analogous with the observable world and an ontological belief is held that there is a reality that constrains the outcomes of the experiments on which scientific theories are based. The metaphorical language of models is used to refer to reality, and can achieve predictive success without being an accurate representation of reality. To support this position, Hesse (:133) refers to the fact that some scientific theories have been successful predictors, but have subsequently been rejected as being false.

Similarly, religious models, such as models of God, refer to realities that are believed to exist. Religious models relate to observables such as 'religious formalities, institutions and experiences, to social-value systems and conditions of cohesion and survival ... which act as constraints on the adequacy' of the models (:133). In addition, religious models can be evaluated in terms of their social effects.

The remaining problem that we need to deal with is the metaphysical questions. To Hesse (:133), 'the relation between the existence of God and social and individual religious experience cannot be exactly the same as that between, for example, physical experiments and the reality of atoms, because we cannot have merely empirical criteria for a religion ... religion involves metaphysics and value systems as well as "facts" '.

This highlights the difference in the methods of empirical science and religion, but when we compare an ideology such as scientific humanism with religion, then the metaphysics and value-systems questions are indeed shared. To press the point home, Hesse (:134) gives the following reasons as to why science (as empirical science) cannot be a new religion:

- Science does not have any rational authority to make metaphysical claims about the origin, destiny, purpose or meaning of the universe. Science's rational authority rests only on the ability to predict empirical data in a limited domain of space and time (e.g. not before a certain time t after the Big Bang).
- If science's models and metaphors are taken to be truths, they become myths, which should be judged in the same way, using criteria outside science, as the myths of religions and ideologies in general.
- These criteria include value judgments about the models of the world that science uses. Science's models are not value-neutral and have often led to a dehumanisation of the world, a devaluation of the significance of human history.
- Religions have been the provider of frameworks for metaphysical and moral issues, hence providing social functions that have been ignored in modern societies due to the scepticism about any rational authority other than science. Science cannot provide these frameworks.
- To restore the social functions of religions, we need to focus on questions of meaning and value that transcend empirical experience and hence literal language. Therefore metaphorical language needs to be revived together with myths.
- The religious traditions promise much more understanding than the creed of scientific humanism that has an ultimate lack of anything realistic to hope for, and is an ideology close to stoicism. The understanding that our religious traditions can provide is at the level of providing answers to what we should do and what we can hope for, through the intimations of the sacred, things set apart which act as symbols of the sacred for the profane.

In addition, we need to highlight the danger of circular reasoning when relating biblical and scientific ideas (Du Toit 2000:19). Scientific theories are used as a hermeneutical guide to support theism and theism is used as a hermeneutical guide to interpret scientific theories. Since metaphors are the way in which we understand the world, we cannot escape 'the analogical and metaphoric nature of our reasoning' (:19).

As an example of the use of the models of science in weaving together a world-view, a metaphysics and a theology, which also illustrates some of the issues discussed above, especially the issue of levels of explanation, we look at the work of John Haught.

5.2.6 An example of the use of information-based analogies in theology

Perhaps the most complete exposition of the usefulness of informational concepts to theology has been given recently by John Haught.

Haught (2000:73) presents the 'explanatory relevance' of theology in informational terms by viewing God as 'the ultimate source of the novel informational patterns available to evolution'. His approach is that there are different levels of explanation, in this case a 'higher' informational level versus the lower level of mechanical causes. In evolutionary biology for example, a concept such as speciation is not accounted for in terms of biochemical causes. Therefore theologians should not seek 'to render the notions of teleology or divine action intelligible in the same terms that scientific kinds of explanation employ' (:74). The informational analogy for God, as used above, allows 'us to appreciate how the universe as a whole may have some overall meaning or "point" to it without this meaning or "point" needing to be displayed at the same level of investigation at which natural science functions' (:74).

Haught's position is that some version of hierarchy 'remains essential to any intelligible conception of cosmic meaning' (:74). The evolutionists insist that there is no hierarchy, that 'evolution pancakes the illusory sacred hierarchy down to the one-dimensional plane of impersonal natural processes' (:75). Haught (:75) proposes that studying how information works will let us grasp 'how a hierarchical shaping of meaning and purpose can become implanted in an evolving universe without having to be obvious at the level of scientific inquiry'. The key issue for Haught (:75) is that information 'works' by 'comprehensively integrating particulars ... into coherent wholes' and therefore 'any attempt to specify the comprehensive function of informational patterns in terms appropriate only to the comprehended particulars themselves is logically contradictory'. The origin of information and its integrating capacity is in another logical space to that of atomic details[65] (:76). Haught agrees that 'information is a mystery that science cannot comprehend through its atomising reductions' (:76). To the charge that information is just a mental abstraction, Haught's answer is that information is 'the very real (though scientifically unspecifiable) foundation of anything being actual at all. Form or pattern, as philosophers from Aristotle to Whitehead have noted repeatedly, is a metaphysical aspect of things, one without which they would have no actuality at all' (:76). Information performs a patterning of the world, creating comprehensive wholes, but cannot be dissected by modern scientific thought in a mechanistic way. However, information is essential to science, which has to assume that nature is informed in such a way that our minds can understand some of nature's information.

Haught (:76-80) turns to Taoism to try to show how information works. Tao, the ultimate reality, is passive energetically, but is active informationally, giving the world structure and function. This way of working is via *wu wei* or active inaction, non-interfering effectiveness (:78). Tao influences even though it is not a thing, it is non-being, just as the empty space of a container allows it to contain things. Haught (:79) suggests that 'information can pattern the universe, and even endow it with hierarchically distinct features, in a similarly non-invasive, utterly humble manner. And it may do all of this without interrupting in any way what from a purely scientific point of view must appear as an unbroken continuum of atomic elements or historical becoming'. The key issue now is that Taoism teaches that we will only understand the hierarchical patterning of the world if we have 'undergone a personal transformation' and 'learned the wisdom of *wu wei*', moving away from a 'controlling way of understanding' to a sensitive and humble way of understanding (:79). Haught (:79) points out that Christian faith also intuits that God creates and acts via 'the manner of humble self-restraint rather than crude intervention'.

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[65] Note that we can conceptually describe even the so-called atomic details in terms of information as well, refer to Subsection 5.6.7: *The universe as a computer*.

Haught's conclusion is that we need not agree that 'evolution logically rules out a hierarchical metaphysics' and that we can 'embrace consistently both a religious vision - including a sense of cosmic meaning - and the carefully established results of evolutionary biology' (:80).

In terms of our question: Can information bridge the gap between science and theology?, Haught's answer is that you need to change your metaphysics first, your way of understanding the world, before information can be used as a concept that can describe the hierarchical patterns and the atomic details. The gap can only be closed if you agree that there are two different explanatory levels. Again the concept of information actually being *active*, creating patterns and structured wholes, comes to the fore. We have referred to this as shaping information[66]. The concept of information on its own, even by means of its many and varied definitions, cannot carry the load of bridging the gap. A whole system of thinking about the world, about God and about God's interaction with the world, is required, within which the concept of information can then be used as part of the language of the system.

We have discussed the issue of the development of a common language as possibly being able to help bridge the gap between science and theology. John Haught's work has expanded the issue to that of levels of explanation, metaphysics and world-views. In the process, he clarifies the domain of application of theology. This brings us to another way of bridging the gap, namely through the redescription or re-understanding of just what theology or science should be concerning itself with. The most common approach has been to expand the reach of science.

5.2.7 Bridging the gap by expanding the reach of science

The work of Davies and Dembski is relevant here. As we have seen in our discussions of their work[67], Davies and Dembski agree that there is a deep mystery that science has not explained, namely the origin of life. This mystery can be cast in information terms as the problem of how highly complex and highly specified entities

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[66] The concept of active information is discussed in Subsection 5.6.4.

[67] Sections 4.2 and 4.3.

arise. Dembski has cast this into the notion of complex specified information. Dembski and Davies (2000:254) agree that the current laws of physics are simple and general and cannot lead to highly complex and highly specific entities. The ordinary laws cannot create information. From this point onwards their paths diverge. Both want to expand the reach of science, but in different ways.

Davies (2000:259) wants to propose a new type of law, an information-generating law, a 'complexity law' that will kick in at a certain level of complexity, leading to jumps in self-organisation and complexity, and perhaps towards life.

Dembski (1999:105) denies that *any* type of law will ever generate information, especially complex specified information, and wants to expand the reach of science beyond natural causes to *intelligent* causes as well. The rationale behind this is Dembski's aim of proving that a designer exists who is the source of the complex specified information. Dembski's theological approach comes into it as well. His contention is that God's interaction with the world *is* detectable, and to go even further, is *empirically* detectable by the methods of science (:105). Behind this approach lies his apologetic intention as he makes clear as well. He chooses this route since science is regarded as the only valid form of knowledge in our culture, the only commonly accepted way to make cognitive claims (:118). To Dembski, then, this is the way to bridge the gap between science and theology, as claimed in the title and subtitle of his book, *Intelligent design: The bridge between science and theology*.

So, when confronted by the mystery of the origin of biological information, Davies the scientist advances a tentative and vague extension of the laws of science, staying within a (slightly extended?) naturalistic framework, whereas Dembski, driven by his theological agenda, makes a bold claim of certainty that we can use the methods of science to prove that a designer is the cause, that science is incomplete as an explanatory system.

Dembski's approach can be seen as yet another variant of a God-of-the-gaps approach. Dembski claims that he has raised the barrier too high, that science will never explain complex specified information since there are no information-producing laws and the probability is too low, ruling out chance. To my mind, Dembski does not want to seriously consider the science of complexity since he does not *want* to be proven wrong, he wants to confirm his hypothesis and does not want to consider seriously possible alternative explanations. A true scientific approach is more tentative, acknowledging that we know very little.

We have now concluded our general discussion on how information concepts can be used to bridge the gap between science and theology. We move on to the first in our list of specific areas in which information concepts have been used, namely in enriching our understanding of God.

5.3 Enriching our concept of God

The Dutch scientist Dippel was one of the earliest users of information concepts in theology and he considered God as the 'sublime "Informaticus", the ultimate information source which creates order out of chaos', the God who is Word and is Information (Van der Lubbe and Laurent 1992:87). This concept of God as the source of all information is quite popular. Gitt uses it as well, as we have seen in our discussion of his work. Two models are normally used here: the model of information as the result of an ordering process (which is assumed to be the result of intelligence) and the notion of a communication process, in which a sender and a receiver are involved. Barbour (2000:150) has noted that the theological models of God in the Bible includes the model of God as a communicator 'expressing meaning and rational structure through the divine Word'[68]. In the science and theology dialogue, the model of God as communicator of information who does not clash with scientific laws, has been proposed by Polkinghorne and a few others (:61). Apart from a brief mention of Gitt and Dembski, our focus will be on the innovative use of information concepts in work based on process theology.

Gitt works extensively with the model of sender - channel - recipient and brings in the issue of volition as well. God's Will is the cause of the information that led to all of creation (Gitt 1997:48, 137, 162-3).

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[68] The *logos* concept is discussed in Subsection 5.6.5.

Dembski focuses more on the issue of information as evidence of intelligent design, thus pointing towards a designer. This does not introduce a new concept of God, but does highlight the nature or mode of operation as being design. This mode of operation is linked by Dembski to the *logos* concept and he gives a full exposition of it. However, one needs to be careful in using this approach to try to prove the existence of God. Pennock (2000:303) has criticised the creationist approach since it reduces God to 'a scientific object'.

The Latin root of the word information, *informare* (meaning giving form to, informing) can also be used here to extend understanding of the way this source of information operates (Van der Lubbe & Laurent 1992:87). We have referred to this type of information as being shaping information. Van der Lubbe and Laurent (:86-88) have extended this thinking by taking a process-oriented view of the world and developing ideas corresponding to process theology.

There is a linkage between scientific developments, the nature of our societies, our world-view and our concept of God (Van der Lubbe & Laurent 1992:84). We can divide our history into the Matter Age, the Energy Age and the Information Age (:84). The world-view has changed accordingly from a mechanistic view to an information and information process-based view. The concept of God in the Matter Age was resonant with the prevailing world-view and a mechanistic view of 'God the clockmaker' could be postulated. In our time, God's image is much more hidden and the close relation between world-view and view of God has been broken (:84). The information-based world-view does provide new scope and context for a new view of God. The move has been from an object-oriented mechanistic world-view to a more dynamic information process view, with a focus on events rather than on objects, and this leads to the possibilities of a 'more dynamic idea of God' (:85).

Van der Lubbe and Laurent present their information-based world-view as a world 'built up from events, related to each other by time-space relations and which are concrete realisations from sets of possible events. Speaking more philosophically, one can say that events are the result of the melting together of possibilities and factualities'[69] (1992:86).

When we look back at the sequence of events, it becomes clear that 'a selection has been made from a number of possible events' and looking ahead, there is a set of possibilities from which to select, therefore reality can be seen as 'an advance of creation' (:86-87).

Having established the background, Van der Lubbe and Laurent focus on the process of communication, and, in contrast to the approach of Dippel, on the two-way aspects of communication as well as the role of the receiver (1992:87). The receiver is also important, since the receiver determines what information is due to the fact that information is translated/decoded by the receiver and hence the receiver's ability to understand is the ultimate limitation. Communication from the receiver to the sender must also be considered.

They therefore see the relation between God and the world as dynamic, two-way communication. God is 'the one who limits the multiplicity of unbounded possibilities and unifies them in the ordered cosmos. Then each event is, on the one hand, the result of an offer of possibilities by God and, on the other hand, the result of what the creating genesis has already brought about' (Van der Lubbe & Laurent 1992:87). This God influences the world and is influenced by it, as in process theology. Here we have a God who is not outside the world, pouring in information, as may be construed if too much emphasis is placed on God as the source of information.

Yes, God is the ultimate source of information, but this involves creating of possibilities and then inviting humankind to make selections, which are not

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[69] As Polkinghorne (1996:27) explains process metaphysics: 'the fundamental metaphysical unit is the event ("an actual occasion"), which has what is called its prehensive phase (the "survey" of the possibilities of the open future in relation to the events of the past and the divine "lure" to a certain direction of occurrence) and the concrescent phase (in which one of these possibilities is actualized)'. See also the discussion on process theology in Chapter 6.2.5.

determined *a priori* (Van der Lubbe & Laurent 1992:88). The selections made have an effect on God by reducing the set of possibilities on offer since each selection excludes all of the subset of possibilities.

In reaction to what he views to be impoverished human concepts of order and design, Haught (2000:6) calls for a fundamental rethinking of our concept of God. Based on the evidence of the chaotic fossil record, God cannot be simply viewed as the source of order. Haught shares with Van der Lubbe and Laurent a process view of the world and postulates (:6):

- a God who is not only a source of order, but also the 'disturbing wellspring of novelty'
- a cosmos that is not just an 'order' (according to the original Greek meaning) but 'a still unfinished process'
- a God whose prime aim is not that of imposing designs but who would rather provide opportunities for the cosmos to participate in its own creation.

As we have mentioned in the previous section, Haught (2000:73) views God in informational terms as 'the ultimate source of the novel informational patterns available to evolution'.

In order to really understand Haught's concept of God, we must understand his view of reality, his 'metaphysics of the future' which gives priority to the future and not to the past or present (2000:88-89). Haught's position is that true novelty arises out of the future and not out of the deterministic and mechanical unfolding of the past, what he calls a 'metaphysics of the past'. Haught is saying that algorithmic processes, the actions of the laws of nature, are not enough to produce novelty. This is fundamentally what Dembski and Davies are saying as well. Furthermore, if we try to reverse engineer (which is an inherently reductive, and atomistic, technique) existing complex systems such as living beings, we will abstract away the organisational principles and informational patterns we are trying to discover (:87). Haught (:200) makes the point that we start with a 'meaningfully patterned totality' and that as we move back into the past in our reverse engineering process, 'the pattern itself dissolves' since 'it was there in the first place only in the mode of being anticipated', of being the target as it were. Pattern or information is 'that towards which evolving processes move' and the ontological status of information is fundamentally future (:200).

The active role of chance is also denied. Haught states: 'It is not the occurrence of contingency that brings about the future; rather, it is the arrival of the future that allows events to have the status of contingency, that is to be more than just the inevitable outcome of past deterministic causes' (2000:87).

Thus the metaphysics of the future is rooted in the intuition that ultimate reality is 'not limited to the causal past nor to the fixed and timeless present', but 'is to be found most characteristically in the constantly arriving and renewing future' (:88). To Haught (:88), this vision can encompass both the evolutionary data and the claims of religion regarding how a 'promising God relates to the world'.

This metaphysics of the future is rooted in the experience of religious people that they are grasped by 'that which is to come' (Haught 2000:89). Haught (:89) quotes Paul Tillich as describing some religious experience as a sense of being grasped by the 'coming order'. Haught (:90) calls this future that meets us, takes hold of us and makes us new, 'God', which is the 'Absolute Future' that is beyond our provisional futures. Not only people but also the whole of creation 'is always being drawn by the power of a divinely renewing future' (:90) (see Rom 8:22 as well). Haught's 'metaphysics of the future' is the philosophical expression of the religious intuition that 'all things receive their being from out of an inexhaustibly resourceful 'future' that we may call "God" ' and 'the notion that the cosmic present and past are in some sense given their status by the always arriving but also unavailable future' (:90-91).

Haught (2000:127) concurs with Whitehead's cosmology that God is the 'ultimate repository of *all* the occasions that make up the cosmic process'. Each occurrence in the world process thus contributes novelty (information?) to God's big picture, what Haught calls being 'harvested into the divine experience in an ever intensifying aesthetic pattern' (:128). This analogy is normally encountered in the form of the tapestry argument, where seen from the back the tapestry does not make sense since the pattern cannot be seen, the information is limited, whereas from the front the beautiful pattern can be discerned and understood.

In summary then, Haught's understanding of God is that God is the 'Absolute Future' which is 'the source of new being, ... the source of the destabilising and always surprising "informational input" that slips into each present' (2000:144).

My view is that God is the creator of the ultimate context within which data is transformed into information. To illustrate this point we can refer to the first volume of the trilogy of four books, the *Hitchhiker's Guide to the Galaxy* by Douglas Adams, in which the answer to everything, the ultimate answer, is given as being '42' (Adams 1979:135). The joke is, of course, that this is a meaningless answer since a number without context can mean so many things! We immediately want to ask: 42 of what? Is it 42 gods, 42 kilograms, 42 kilometres, 42 civilisations, 42 laws? Our cosmos seems to be a mixture of order and disorder and is very difficult to understand on its own terms. God could conceivably provide the context that will ultimately allow everything to make sense.

Our concept of God can always only be partial. What we have here is simply an exploration of the new resources, the new concepts that science has given us.

We now move on to another broad area in which information concepts have been used to gain understanding, namely the concept of life.

5.4 Clarifying our concept of what life is

We have focused on biological information as the new arena of the divine action debate and hence we have already covered a wide spectrum of opinions and uses of information concepts[70]. We will here just summarise some of the main lines of thought.

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[70] See, for example, the discussions on Gitt (Subsections 4.2.5, 4.2.7.1, etc.), Davies (Subsections 4.3.2, 4.3.4, 4.3.5) and Dembski (Subsection 4.4.8.5).

The central issue has been that the origin of life remains a mystery and that information plays a key role since the real secret of life is that a living organism is a complex information-processing system. We have noted that scientists are in fact reluctant to admit in public to the remaining mystery of the origin of life, since they do not want to open the door to 'religious fundamentalists and their god-of-the-gaps pseudo-explanations' (Davies 2000:18).

Apart from the actual understanding of how this information processing works, the ultimate problem remains the issue of where biological information came from. Gitt and Dembski have homed in on this question and have used it as the source of arguments for the existence of God, as the Sender of Information (Gitt's position), or, at least, for the existence of an intelligent designer (Dembski's position).

The context of this source of biological information is not simply that very first location and event when life came into being, but is actually the whole universe and its history. Biological information is information with a context or meaning, i.e. semantic information (Davies 2000:60). If we assume that the source of semantic or meaning information can only be the environment of the living organism, then ultimately the environment is the whole universe, so we need to know the origin of the information content of the universe. In addition, quantum mechanics and relativity theory suggest that information is a global rather than a local physical quantity; therefore, if there *are* information laws, they must be non-local.

With regard to our understanding of how the first information-processing system came to be, Davies has shown that the top-down (delving back to the possible origins of today's complex systems)[71] and bottom-up (building complexity from scratch) approaches do not meet: there is a gap in our understanding. This gap is due to what is called irreducible complexity or 'enigmatic circularity' (Davies 2000:124).

There are some lines of exploration that may solve this mystery. The study of complexity has led to theories of self-organisation and principles of complexity seem

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[71] The top-down approach is discussed in Subsection 4.3.4: *From chemicals and energy to self-organisation*, and the bottom-up approach in Subsection 4.3.5: *From self-organisation to life*.

to have been discovered. The work that is being done in the area of developing artificial life via computer models holds promise as well[72]. Quantum mechanics is another field with tremendous potential to surprise us. There is, however, no certainty that we will solve the mystery of life.

To conclude this overview, we mention a few of the more speculative theories that involve information.

Biosemiotics[73] is a radical view on what life is. It studies the dynamics of living systems from the perspective of communication or the exchange of signs. Life is simply a network of sign processes. It holds the promise of interconnecting natural entities and processes into a web of relations that span the hierarchical scale from the cell to the biosphere. The focus is on information as being always *for* someone (an intentional creature).

Frank Tipler[74] has achieved a certain amount of fame with his views on the ultimate destiny of the universe and how intelligence as information-processing capacity may conceivably survive the end of the universe. Life, according to him, *is* information processing (Tipler 1994:124). His 'Omega Point' concept, the completion of all existence, will preserve all that has ever been thought and done by any intelligent entity and could resurrect them again as well (:12, 110, 219).

We have touched on some of the different ways in which information concepts are being used to describe the mystery of life. Despite the title of this section, I do not believe that the mystery has really been clarified yet. We do have a better sense of the depth and breadth of the mystery and have started to understand some of the underlying principles of complexity. In the next section a brief overview is given of

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[72] Cellular automata, an artificial form of life, are discussed in Subsection 5.6.7.5: *Cellular Automata.*

[73] See Section 2.3: *The biological roots of information - from biosphere to semiosphere.*

[74] His book, *The physics of immortality*, published in 1994, contains a complete overview of his ideas. The universe started with a mathematical singularity and may end in a mathematical singularity as well, which Tipler has called the 'Omega Point'. At the very end, the universe will basically be a computer of ultimately infinite processing-power. The term 'Omega Point' is taken from the work of the Jesuit philosopher-scientist Pierre Teilhard de Chardin (Tipler 1994:110).

the role that information-based theories play in describing and linking the hierarchical levels of complexity, from atoms to communities.

5.5 Linking the hierarchy of organisational levels

Schmitz-Moormann (1992:172-184) sketches the evolution of information by highlighting the growing separation between information and its physical infrastructure as systems grow more complex. This idea is explicated in the table on the next page. The table provides an overview of the hierarchical levels of organisation and relevant scientific theories and religious concepts.

Levels of organisation	Integration of information and structure	Relevant theories	Concepts used in the science and theology dialogue
Religious communities (God and people)	Information is efficient, but not linked to a definite material infrastructure, experienced as a spiritual reality.	Divine inspiration - theology.	God as ultimate source of information. God is Word, Information. Revelation as information (Dippel). God as the ultimate boundary condition (Barbour 2000:111). Openness to the divine. *imago dei*.
Humans, language communities, society	Multiple ways of carrying information. Storage is completely independent of the organism. You know that you are informed. Creating new information. Global information networks form.	Linguistics. Semantics, meaning.	
Animals	Perception of the "outside". Complete separation of structure and information.. The message is created by the organism in its own unique form. Information no longer fixed to a specific way of communicating it. Signs!	↑ Theory of communication .	
Living organisms	Difference appears between information and structure as the information carrier (e.g. DNA). Communication starts.	↑ Biosemiotics. Cybernetic view of communication - information (e.g. DNA) as part of feedback system. Systems thinking: Top-down causation happens when higher-level events impose boundary conditions on lower-level processes, resulting in information flow.	Life = information processing Open vs closed systems. Top-down causation: God acting as a top-down cause 'without violating the laws describing events at lower levels' (Barbour 2000:111). God as communicator. Active information.

Levels of organisation	Integration of information and structure	Relevant theories	Concepts used in the science and theology dialogue
Autocatalytic systems	Dependencies between structures develop. Correlation vs. interaction. Differentiation can be made between information, information storage and information transmission.	↑ "Laws of complexity". ↑ Mathematical information theory.	Hardware and software
Macromolecules	Structure becomes ever more complex - distinction between information and structure starts.		
Molecules and atoms	With molecules, the structure becomes more important than the raw material. The particle is the message - information cannot be separated from the structure.		
Matter, energy and information.	The basic building blocks are matter, energy and information. The basic information of the universe is the physical constants.	↑ The laws of physics. ↑ Quantum mechanics.	God informing, giving form to everything

John Haught (2000:185) makes the key point: 'information allows logically for distinct kinds of being and grades of value within what ... may seem to be an unbroken continuum of atoms' (:70, 75). That there are discontinuities in the separation between information and structure appears to be intuitive. This position can be described as a reaction to ontological reductionism, which, in this context, claims that the world consists of atoms and forces only. Barbour (2000:109) has defended what he calls 'ontological pluralism' which is 'a multileveled view of reality in which differing (epistemological) levels of analysis are taken to refer to differing (ontological) levels of events and processes in the world, as claimed by critical realism'. Jeffrey Wicken holds the following view of nature: 'Nature produces itself hierarchically - one level establishing the ground of its own stability by using mechanisms made available by lower levels, and finding functional contexts at higher levels' (as quoted by Barbour 2000:106-107).

Barbour (2000:108) distinguishes between a *structurally defined* hierarchy (quark, nucleus, atom, molecule, macromolecule, organelle, cell, organ, organism and ecosystem) and a *functionally defined* hierarchy, such as the reproductive hierarchy (gene, genome, organism and population) and the neural hierarchy (molecule, synapse, neuron, neural network, brain and body). In addition, humans participate in social and cultural interactions, a network of effects that we call culture? In general, process philosophy stresses that the various levels of organisation 'may be integrated according to very different principles of organisation, so their characteristics may be very different' (:147). With the hierarchy as sketched here, the intention was to make just the one main point, namely the separation between information and its physical infrastructure. Each level also represents a different *context* with different *relationships*, which means that information and meaning, which are context and relationship-dependent, will continually change as well.

From a systems thinking perspective, information plays an important role in actually maintaining the hierarchy. Hierarchies employ a set of processes to regulate and control the use of the communication of information (Checkland 1981:83). The link between control and communication, and emergence and hierarchy is especially evident in biological systems (Checkland 1981:86). The action of control is associated with the imposition of constraints, which immediately requires a two-level hierarchy, with the upper level imposing constraints on the lower level. Checkland (:87) gives the following example: 'the cell as a whole constrains the physico-chemical possibilities open to DNA and makes it "the bearer of a code". The upper level is a source of an alternative (simpler) description of the lower level in terms of the specific functions which are emergent as a result of the imposition of constraints'. The function of DNA is not inherent in the macromolecule itself, but is the *emergent* result of a hierarchical control process.

We now move on from life to another broad area in which information concepts have been used to gain understanding, namely the issue of God's action in the world. We have already covered biological information and molecular biology extensively and hence will focus on other aspects of God's interaction with the world.

5.6 Understanding God's interaction with the world

5.6.1 Introduction

The most recent dialogues on the issue of God's action in the world have focused on quantum indeterminacy, chaos and complexity, especially self-organised complexity, with various models of either top-down or bottom-up causation or combinations thereof. We will not cover these models extensively, but only focus on the role that information plays in these models. We start off by examining the debate about interventionist or non-interventionist positions.

5.6.2 Interventionism vs non-interventionism

How to avoid interventionist accounts of God's action in the world is the dilemma that is faced by, especially, the scientist-theologians, who, as Polkinghorne states:

> ... wish to speak of God's action in the world in a way that goes beyond the single act of upholding the universe in being. Providential agency must be continuously at work in a way consistent with the known laws of nature (themselves understood theologically as expressions of God's faithful and

unchanging will for his creation). We all[75] refuse the word 'intervention', and accept the word 'interaction', as the way to speak of divine acts.

Polkinghorne (1996:41)

Polkinghorne (:41) refers to 'acts of intellectual daring in the quest for a causal joint' that 'seem necessary if we are to go beyond mere fideistic assertion'. These acts are 'attempts to take both matter and providence seriously' (:41).

Robert Russell (1998:191-192) is one of those who have taken up the challenge of trying to talk of God's special providence or special action, without being 'forced to argue that God's special action constitutes an intervention into these processes and a violation of the laws of nature which God has established and which God maintains'. Russell (:192) talks of the seemingly unavoidable connection between special providence and intervention as having led theologians to a 'forced option'. Liberals have restricted talk of God's action 'to our subjective response to what is really only God's uniform general action', thus avoiding interventionism, but reducing God's action to a 'uniform, single enactment at best, often drifting to a kind of deism' (:192). Conservatives, on the other hand, argue that special providence is God's objective 'acts in history and nature attested to by faith' (:192). They accept the price of being called interventionists.

Russell refers to the debate around the role of chance in evolution as an example to get to the heart of the dilemma. People such as Dawkins claim that chance pervades biological evolution and hence any talk about God's action is unintelligible (Russell 1998:192). The liberal response is that God creates through the 'combination of chance and law', but Russell contends that 'chance' actually signifies our ignorance of what are complex deterministic processes (:192). So, if one regards chance as 'only epistemic ignorance and nature is really a closed causal system', then to claim that God acts through chance in evolution, and not just at creation, leads to an impasse in which it either means nothing, since nature's laws operate without any need for other inputs, or you are forced to adopt the option that God *does* intervene in nature, by acting in gaps in the closed causal order (:192). The latter position is the conservative

[75] Polkinghorne is referring to Arthur Peacocke, Ian Barbour and himself.

position that threatens the dialogue with science and in fact can strengthen the atheist position since, if you attack Darwinian evolution and try to replace it by creation science or intelligent design[76], you are agreeing that it is Darwinism *itself* that must be attacked or replaced, and not its atheistic interpretation (:192). Russell (:192) feels that 'theistic evolution offers the real attack on atheism by successfully giving a Christian interpretation to science - thus undermining the very assumption they share with atheists, namely that a Darwinian account of biological evolution is inherently atheistic'.

Having made this diagnosis of the root cause of the dilemma, Russell (1998:193) argues for another option, namely a 'non-interventionist understanding of special providence'. This position is based on an interpretation of nature as being ontologically indeterministic, so that nature is *not* an entirely closed causal system. To Russell (:193), the discoveries of quantum mechanics seem to indicate that, at least at one level – the quantum level, nature is undetermined, since quantum physics is irreducibly statistical. There are thus what Russell (:193) calls 'natural gaps' in the causal regularities of nature. In the context of evolution, chance, 'at the level of quantum mechanics underlying genetic mutation, is then a sign of ontological indeterminism and not of epistemic ignorance' (:193). Russell (:193) says that 'we can view nature theologically as genuinely open to objective special providence without being forced into interventionism' and he calls this view a 'non-interventionist view of objective special providence'.

We will now discuss the details of this 'bottom-up' approach, which focuses on the quantum level, before moving on to Polkinghorne and Peacocke's notion of active information, which deals with other levels of nature as well and is an example of the 'top-down' approach.

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[76] Russell's argument has also been used in the appraisal of Dembski's work (Subsection 4.4.9.3) and in the discussion on interpretations and points of departure in Section 6.1.

5.6.3 Quantum indeterminacy

The focus on quantum indeterminacy as the arena in which God can exercise providential control without violating any physical laws has a long history. William Pollard proposed such a model for divine action in the 1950s (Barbour 2000:86, Russell 1998:208-209). Nancey Murphy, Thomas Tracy and Robert Russell have been influential proponents (Murphy 1995, Tracy 1995, Russell 1998). In the context of our overall focus on biological information, it makes sense for us to discuss Russell's explanation of how God can act purposefully, without disruption, within the processes of biological evolution at the quantum level.

Russell (1998:193) has spelled out the benefits of seeing chance at the quantum level as ontological indeterminism. God's special action can then result in 'specific, objective consequences in nature', but since the quantum laws are 'irreducibly statistical', these consequences would still be consistent with the laws of science, while at the same time God's action will not entail the disruption of the processes due to their indeterminism. The specific claim that Russell (:195-196) makes is that God's special actions 'occur directly at the level of, and are mediated by, those genetic variations in which quantum processes play a significant role in biological evolution'. To support this claim, Russell (:196) needs to show that 'quantum processes may be interpreted philosophically in terms of ontological indeterminism and that quantum processes are relevant scientifically to genetic variation'.

The whole point of quantum physics is that it challenges our normal understanding of chance that is epistemic - we call it chance when we do not know all the factors that caused an event to happen, but we believe that in principle we could have predicted the event if we had perfect knowledge of all factors (Russell 1998:200-201). Although there are many competing interpretations[77], Heisenberg's view that 'quantum chance points to a fundamental ontological indeterminacy in nature' is strongly

[77] Some examples are Bohr's Copenhagen interpretation which imposes fundamental limitations on epistemology, and Everett's 'many-worlds' interpretation (Russell 1998:201).

supported[78] (:202). This means that the 'use of statistics in quantum mechanics is not a mere convenience to avoid a more detailed causal description', but that 'quantum statistics is all we can have, for *there is no underlying, fully deterministic natural process*' [Russell's italics] (:202). A quantum system is then best described in terms of potentialities and actualities, where out of the superposition of 'coexistent potentialities', one of them becomes actual at a specific moment in time (:203). Just how one of the potentialities is selected to become actual is what cannot be causally explained by the interaction of the system with its environment. This leads to the possibility that 'we can view nature theologically as genuinely open to God's participation in the bringing to actuality each state of nature in time' (:203). As Russell (:203) puts it, 'where science employs quantum mechanics and philosophy points to ontological determinism, faith sees God acting with nature to create the future'. In information terms, the selection amongst probabilities amounts to the input of information. Russell (:203) describes this action of God as realising the promised future for all creation by 'acting specifically in all events, moment by moment'[79]. The next question is how these quantum events can have larger-scale effects.

The easiest example is vision. Your eye can actually detect a single photon. In terms of our question as to how quantum processes are relevant to genetic variation, the starting point is mutations of DNA during replication, which is the ultimate source of genetic variation (Russell 1998:205-206). We can speculate that point mutations in the DNA arise 'from the interaction of a single quantum of radiation and a single proton in a hydrogen bond in a specific base' (:207). The point is that it is possible that effects at the quantum level can cascade up to the macroscopic level, although there are many uncertainties and other factors, such as the environment, definitely also play a role.

[78] Polkinghorne (1996:34) confirms that 'almost all physicists and philosophers treat Heisenberg's uncertainty principle (which was initially an epistemological discovery about what can be measured) as an ontological statement of quantum indeterminacy'.

[79] Russell (1998:203) mentions that process philosophy, like other metaphysical systems, can fit well with quantum mechanics, since process metaphysics can suggest that the 'openness of these quantum states includes the efficacy of inherent novelty or creativity, along with God's lure and the necessary conditions of the causal past'.

We have now sketched the lines of an argument for the theological view that God can act in a special way that is non-interventionist, provided that nature is held to be ontologically indeterminate[80]. Again we can formulate this 'bottom-up approach in informational terms as being the input of information at the quantum level. Russell's overall approach is an example of a theology of nature, a concept we discuss further in Chapter 6[81].

A vast quantity of literature has grown around the possibilities offered to theologians by the quantum world, but we will here only briefly mention some implications that can be drawn from an information point of view.

Ian Barbour (2000:166-167), like many others, makes the point that selecting amongst the many possible alternative potentialities present in the quantum world conveys information *without* energy expenditure. As Barbour (:166) indicates, in quantum theory there is actually zero energy difference between potentialities[82]. Barbour (:166) also argues that if God is omnipresent, then no energy is required for the communication of information, in contrast to all other communication systems in which the transmission of information between two points requires energy. An example of omnipresence, or of a truly global entity, is the wave-function that is used in quantum mechanics to describe the wave-like aspects of matter; it contains all that is known about a system, it represents the information content of the system (Davies 2000:66). As discussed in Section 4.2, a key feature of the wave function is that it is spread out over space. For example, two particles that have been 'entangled' are

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[80] We do not have the scope in this dissertation to go into all the counter-arguments against this position such as theodicy, occasionalism, etc., but Russell (1998) does provide extensive responses. It is also worth noting that Russell (:217) adopts a trinitarian and panentheistic view of God - a God who is 'supremely active in all reality, as its absolute origin (first person), the form and wisdom which structure and guide its processes (second person), and the power which sanctifies and empowers it towards completion (third person). According to this view, God cannot intervene 'because God is already universally present in nature' (:217).

[81] Ian Barbour's typology includes a 'theology of nature' under the category of 'integration' and Barbour's comments on Russell's work as an example of integrationare discussed in Subsection 6.2.5.

[82] Barbour (2000:87) has also explained this issue as follows: 'Since an electron in a superposition of states does not have a definite position, no force would be required for God to actualize one among the set of alternative potentialities.'

coupled to each other even if they are at opposite ends of the universe. This provides yet another example of the truly mysterious nature of the universe.

5.6.4 Active information

Peacocke and Polkinghorne view the concept of active information as the key model for describing God's interaction with the world[83] (Polkinghorne 1995:105). God's influence is then seen as an input of information rather than of energy, thus avoiding the charge of interventionism, and a link is made with the commonly used theological language in which the Spirit is described as guiding or leading creation (Polkinghorne 1995:105, Peacocke 1995:113). The advantage is that God is thus not reduced to a demiurge, which acts as just another physical cause among others (:105).

Active information seems to be a very difficult concept to pin down, as can be seen from the different stances taken by Peacocke and Polkinghorne. Peacocke (1993:164) simply suggests that 'the influence of God on the world-as-a-whole might be appropriately conceived of in terms of a flow, an "input" of information rather than energy'. Polkinghorne (1995:105) is at pains to distinguish it from Shannon's information theory, in which information is the measure of the transmission of the specification of pattern, or what we have called 'counting information'. According to Polkinghorne (:105), the concept of active information is 'obtained by taking the notion of chance in behaviour pattern brought about through the effect of infinitesimal disturbance and extrapolating it, in a metaphysical conjecture, to the case of zero energy-input'. Polkinghorne (1996:36) has described the origin of this idea as being the supplementation of energetic causality with 'holistic causal principles of a pattern-forming kind, leading to what might be called "active information": "active", because the holistic principle brings about actual future behaviour; "information", because its action relates to structure rather than to energetic properties'.

Polkinghorne (:107) has to distinguish between active information and Shannon's concept of information (counting information) since Brillouin and Szilard have shown

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[83] The use of the concept of 'information input' for God's way of inducing effects in the world was pioneered by John Bowker (Peacocke 1996:328).

that in order to input information, an irreducible input of energy is needed[84]. Polkinghorne's concern is that if God has to input energy to input information, we are back at the demiurge again. Peacocke (1993:370) agrees that this is problematic since, 'in the real world we seem to know of no transfers of information that do not involve exchanges of matter/energy'. Peacocke (1993:164) says that 'This seems to me to be the ultimate level of the "causal joint" conundrum, for it involves the very nature of the divine being in relation to that of matter/energy'.

Peacocke's way out of this conundrum is by viewing the concept of active information as being an extension of the concept of information as used in communications theory, rather than being qualitatively distinct from it as per Polkinghorne's view (Peacocke 1995:113). Peacocke (:113) extends the concept of information by using Puddefoot's analysis[85]. The use of information in the information theory sense (Shannon or counting information) can be regarded, as Peacocke (:113) formulates, as 'explicating the underlying processes ("input" of information) which give shape or form (that is 'informing' in another sense) to the brain processes that are our mental experiences, some of which constitute our knowing'. Peacocke (:113) says that 'When God's interaction with the world, shaping patterns of events, is conceived of in these terms, then the way is open to enriching and making more intelligible our idea of God's self-communication to the world and furthermore to a fruitful linkage with the theological concept of God 's self-expression as the "*Logos* of the cosmos"'.

Polkinghorne (1995:108) refers to the 'supposed' problem and believes that here we actually might 'perceive some faint clue about what is special in the Creator's interaction with his creation and why the language of Spirit is traditionally employed'. Polkinghorne (:1996:40) says that the problem of minimum energy expenditure relates to the 'passive information record, which is not the same as pattern-forming active information'. Polkinghorne draws supports for this kind of distinction from quantum theory, as we will now discuss.

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[84] It was discovered recently that energy is required to erase information, therefore if no erasure happens, no energy is wasted. See Subsection 5.6.7 for more details.

[85] We have discussed Puddefoot's analysis in Section 2.1, together with other definitions of information, and have used it in Subsection 5.2.5 as well.

Polkinghorne's overall model for divine action draws on chaos theory in which an infinitesimally small energy input can result in a big change. The other, possibly complementary, option is to look to the quantum world, which we have discussed in the previous section (Subsection 5.6.3). We can here again note that, as Barbour (2000:166) indicates, in quantum theory there is actually zero energy difference between potentialities, whereas Polkinghorne needs to extrapolate to the limiting case of zero-energy input. Polkinghorne's defence against this line of argument is to refer to Bohm and Riley's version of quantum mechanics in which the 'guiding wave' retains its 'ability to influence the motion of the particle, however attenuated the wave may become' (Polkinghorne 1996:40). This reminds us again of quantum entanglement, where two particles are connected even though they may be at opposite ends of the universe. Polkinghorne (:40) speculates that while embodied beings such as ourselves may need energy to input information, 'it seems coherent to believe that God's action could be in the form of pure active information' and that this would 'afford a particular character to divine agency, consonant with theology's insistence that God is pure spirit'.

It is clear that even though Peacocke and Polkinghorne agree that the concept of active information has possibilities, they do not actually agree very well as to what this concept is. Polkinghorne (1996:90) thinks that none of Puddefoot's definitions 'quite corresponds ... to the concept of active information'. Of course, it is quite difficult to give concrete details of a concept that is so difficult to grasp. We have discussed elsewhere[86] John Haught's attempts to use the concept of Tao to try to show that information works via active inaction or non-interfering effectiveness which provides structure and pattern to the universe. In all of these examples, one's opinion of their plausibility depends on whether one thinks that the metaphysical underpinnings of the argument are acceptable or plausible. Polkinghorne (:37) has rather strong feelings on the subject[87]: he feels that top-down causality is a 'mere slogan' without the 'identification of that openness within the bottom-up description

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[86] In Subsection 5.2.7: *An example of the use of information-based analogies in theology* and in the section on God's action from a process perspective, Section 5.6.

[87] This should not be a surprise coming from a self-confessed 'bottom-up thinker'!

alone that...affords room for manoeuvre for such a holistic form of causation'. This openness must be an ontological gap and not just a gap in our knowledge (:37). Polkinghorne (:37) says that one needs to make the 'critical realist move from epistemology to ontology' to give respectability to one's conjectures. Therefore you have to believe in your ontological gaps: you cannot be sure that what we now think are ontological gaps will not later turn out to have been gaps in our knowledge after all.

We have discussed the most popular candidate for such an ontological gap in the previous section, namely that quantum chance points to a fundamental ontological indeterminacy. It is interesting that Polkinghorne (1996:40) does not opt for quantum indeterminacy when he dares to guess 'about the causal joint by which top-down causality is brought to bear'. The reason for this is that he does not think that the problem of how the classical and quantum worlds interact has been resolved (:37). He opts for a somewhat similar approach, since he assigns divine action to 'a hiddenness within the inescapably cloudy unpredictabilities of physical process, interpreted realistically as the sites of ontological openness' (:40). Polkinghorne focuses on chaos theory rather than quantum theory to follow the popular strategy of using epistemology to motivate ideas about ontology. Polkinghorne (:35) makes a non-deterministic interpretation of chaos theory that is not as familiar as the deterministic one. He bases his argument on the fact that chaotic systems 'are not totally disorderly; their future is contained within the confines of possibility represented by a limited range of behaviour called a "strange attractor"' (:35-36). All these possibilities, or paths traversing the attractor, have the same energy and they differ only in terms of the 'patterns of behaviour they represent' (:36). The other major factor is the well-known exquisite sensitivity of chaotic systems to their environment, which means that such systems must always be discussed in a holistic context. Active information, then, as we have already discussed, is what Polkinghorne (:36) calls the 'holistic causal principles of a pattern-forming kind', that could determine which pattern the system slips into. The deterministic equations that would normally be viewed as being in principle able to describe the behaviour of the system are understood by Polkinghorne (:36) as '"downward emergent" approximations to true physical reality, applicable only on those rare and specific occasions in which the constituents can be treated in isolation from their environment'. This is not often true and the system's behaviour depends on the total situation, environment and equations, and there is a causality that flows from top to bottom and bottom to top. Polkinghorne (:36-37) speculates that there may be 'holistic laws of nature driving the evolution of complexity' and that God might in fact interact with creation in the same way. We have previously discussed similar speculations by Davies about the laws of complexity[88]. What is quite clear is that we have no idea as to how these laws might work, other than to call them 'holistic causal principles', labelling them as active information and, in addition, stipulating that no energy exchange must be involved.

Peacocke does not go into the depths of the causal joint as Polkinghorne did in explaining his view of whole-part constraint. He differs from Polkinghorne in that he thinks that chaotic processes are not the source of openness, rather opting for quantum processes and quantum systems, in which 'macroscopic states arise from a chain of events initiated by a quantum-controlled one' (Peacocke 1995:112).

In the context of the top-down causation theory, Polkinghorne (1995:107) is sceptical of Peacocke's use of dissipative systems (e.g. the Bénard instability in convection). Peacocke tries to show how 'holistic correlated behaviour is compatible with unmodified microscopic process'. These systems show behaviour that is 'still predominantly energetic in character'. Polkinghorne (:107) is looking for 'an ontological influence of context on behaviour' and refers to Ian Barbour's process point of view as well. Peacocke (1995:115) essentially agrees, but his preferred phrasing is 'whole-part constraint'. Higher-level processes plus the boundary conditions of a higher complex whole can result in new functions and capabilities (Peacocke 1995:114). Peacocke stresses that the laws of higher-level processes are *fully* determined by the laws of lower-level processes. Peacocke (:115) agrees with

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[88] Subsection 4.3.9.

Beckner[89] that process and theory autonomy of higher levels vis-à-vis lower levels *inevitably* leads to 'postulating some non-physical causal entity as operating at the higher level over and beyond the effect of the incorporation of the parts into the relationships and under the boundary conditions of the whole which undoubtedly in many cases affects how the parts behave.' This leads one to what has previously been called the 'vitalism position' in the context of describing living entities. Peacocke (:115) is happy to accept this so-called 'weak' anti-reductionist position since the strong position leads to the problem sketched above, and he thinks that Polkinghorne, although he calls himself a strong anti-reductionist, in essence holds the same position (Polkinghorne and Peacocke both deny vitalism). Peacocke (:115) also contends that ultimately there is not much difference between his whole-part constraint and Polkinghorne's downward-emergence.

Within the scope of this dissertation, we cannot do full justice to the intricacies of this debate. We have simply given an overview to indicate the intricate depths to which these debates can go, indicating how difficult these issues are to understand and how the same philosophical position can be labelled differently by different people.

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[89] Beckner distinguishes between *theory autonomy* and *process autonomy* (Peacocke 1995:113-114). Theory autonomy is the autonomy of higher-level theories (dealing with more complex systems) with respect to lower-level theories in the sense that the 'higher are not epistemologically reducible to the lower' (:114). This deals with the relation between scientific language used to describe different levels of complexity, which is what makes it different to process autonomy, which deals with some kind of causal independence, so that the laws of the higher-level processes are *not* fully determined by the different kinds of laws of the lower–level processes. The combination of process autonomy with theory autonomy is described by Beckner as strong organicism or what Peacocke calls anti-reductionism, and that of process non-autonomy with theory autonomy as weak organicism or weak anti-reductionism (:114). Peacocke (:114) characterises his own position as weak anti-reductionism, since he believes that the higher-level processes are determined by lower-levels processes, 'determined' here being taken as meaning that the higher complex whole cannot be explained without taking into account the lower-level processes . This bring us to the quote of Peacocke (:115) that we used in the text above, namely that he is a weak anti-reductionist since he agrees with Beckner that the combination of process and theory autonomy of higher levels vis-à-vis lower levels *inevitably* leads to 'postulating some non-physical causal entity as operating at the higher level over and beyond the effect of the incorporation of

5.6.5 The *logos* concept

There are many references to the *logos* concept in the science and theology dialogue[90]. We need to be careful to in using it out of its original context. As an example, Lucas (2001:181) has castigated Dembski for committing the 'root fallacy' in his discussion of the etymology of *logos*[91]. The etymology of a word can be totally irrelevant and misleading. The meaning of a word is its use in a specific context.

Peacocke's dealing with this problem is exemplary. Peacocke (1993:295) makes the link with the *logos* concept by starting off with the question: 'How could God communicate through Jesus?' He links this question with the problem of God's interaction with the world, which he considers as a 'holistic, top-down continuing process of input of "information", conceived of broadly, whereby God's intentions and purposes are implemented in the shaping of particular events ... without any abrogation of the regularities discerned by the sciences' (:295). People are also part of

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the parts into the relationships and under the boundary conditions of the whole which undoubtedly in many cases affects how the parts behave.'

[90] Barbour (2000:48,54, 60-61, 63, 114, 167, 176) is a good example. In this dissertation we focused on the *logos*-concept in process theology as an example of an *integration*-type approach to the relation between religion and science (Subsection 6.2.5); in the discussion of *Active information* (Subsection 5.6.4); and in the discussions on *Enriching our concept of God* in Subsection 5.3.

[91] Dembski's study of the word *logos* relates to his desire to 'resist naturalistic construals of *logos*' (Dembski 1999:226). He argues that meaning transcends convention (:227). Words are not just contingent and conventional; there is a 'transcendent realm of meaning' to which linguistics entities such as *logos* are attached (:227). He then argues that *logos* resists all naturalistic reductions, since it was a far richer concept to the Greeks than just another linguistic entity (:227-228). One can ask why Dembski focuses so much on the word and not on the whole philosophical system in which *logos* is embedded. Dembski (1999:228-229) discusses the derivation of *logos* from the Indo-European word *l-e-g*. The root *l-e-g* has variants *l-e-c* as in *intellect* and *l-i-g* as in *intelligent*. At the end of his analysis, he comes to the conclusion that: 'According to its etymology, intelligence therefore consists in *choosing between*' (:228). In his complexity-specification criterion he makes a connection between intelligence and choice. This leads him to conclude that 'the etymology of the word *intelligent* parallels the formal analysis of intelligent agency inherent in the complexity-specification criterion' (:228). Dembski (:229) uses etymology to 'prove' that natural selection is an oxymoron since 'it attributes the power to choose, which properly belongs only to intelligent agents, to natural causes, which inherently lack the power to choose'. To my mind, the only thing that this whole exercise proves is that one can prove whatever one wants through the use of etymology.

this world and can also be 'informed' by God through the nexus of events in human-brains-in-human-bodies, and we call it 'religious experience' when the recipient is conscious of this input from God. Peacocke (:296) asks:

> How ... might we then interpret the experience of God that was mediated to his disciples and the New Testament church through Jesus? That is, how can we understand the Christ-event if God's self-communication is to be conceived of in these terms developed in order to make intelligible God's interaction with a world now perceived through the natural and human sciences?

So the challenge is to use new concepts to express what scholars conclude about how Jesus Christ was understood in New Testament times. Scholars such as J G Dunn uses phrases such as 'Initially Christ was thought of ... as the climactic embodiment of Gods' power and purpose ... God himself reaching out to men ... God's creative wisdom ... God's revelatory word ... God's clearest self-expression ... God's last word' (as quoted by Peacocke 1993:296). Peacocke (:296) views these descriptions of Christ as being all about God's communication with humanity, and hence as an 'input of information' from God, or the 'conveying of meaning from God to humanity'.

Peacocke (:296) argues that in New Testament times, Jesus was experienced as God revealed, as God's communication to the world. So, when John interpreted the life of Jesus, he 'conflated the concept of divine Wisdom with that of the *Logos*, the "Word" of God, in order to say what he intended to say about the meaning Jesus the Christ had for the early witnesses' (:296). Peacocke (:296-297) refers to the work of John Macquarrie, who emphasised the 'beauty and aptness' of applying the *logos* expression to Jesus, since *logos*, in addition to the image of 'Wisdom', conflates two other concepts: 'the Hebrew idea of the "word of the Lord" for the will of God expressed in utterance, (especially to the prophets), and in creative activity; and secondly that of "logos" in Hellenistic Judaism[92], especially in Philo - the Divine *Logos*, the creative principle of rationality, operative in the universe and especially manifest in human reason, and which is formed within the mind of God and projected into objectivity'.

This line of thinking is supported by Ian Barbour (2000:48) who states that in the first chapter of John, the 'term *Word* (*logos*) merges the Greek principle of rationality with the Hebrew idea of God's Word active in the world'. According to Barbour, John goes further to connect creation to revelation since he states that the Word became flesh (Jesus). The early church affirmed that the very purpose of creation was made known by God in the life and death of Jesus Christ.

In order to make the prologue to John's Gospel easier to understand and to convey the import of Word/*Logos*, Macquarrie has actually substituted 'Meaning' for it. Peacocke (1993:297) provides Macquarrie's paraphrase (the numbers used below refer to the paraphrased verses of John 1):

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[92] Du Rand (1990:37-42) mentions the many possible influences the Greek and Jewish worlds of thought had on John's Gospel. The Greek influence includes the philosophy of Plato and that of the Stoics, as well as Gnostic thought about the relation between humanity and God, as well as the attempts by Philo of Alexandria to syncretise Jewish, Platonic and Stoic thought (:37-40). The Stoa placed great emphasis on the *logos* concept. The Greek word *logos* means both spoken word and pervading principle. Stoic philosophy focused on the latter meaning, and saw '*logos* as the ordering principle of the universe; the wise person aims to live in harmony with it' (Beardslee 1993:464). Beardslee (:464) cautions that this meaning 'was quickly drawn into the interpretation of John's Gospel as "*logos* theology" developed in the second century CE', since this was a 'principal means of making Christian thought intelligible to its environment; but later *logos* theology was more rationalistic than was the gospel of John'. Du Rand (1990:37) also warns that although John might have used the same terms and thought systems as those of Plato and the Stoics, it does not necessarily mean that he got his ideas from them.

For the sake of completeness, we include the following summary of Stoic philosophy. The Stoa used *logos* as a philosophical term to 'signify the divine power of function by which the universe is given unity, coherence and meaning (*logos spermatikos*), "seminal Word", which, like seed, gives form to unformed matter; man is made in accordance with the same principle, and is himself said to possess Logos, both inwardly (*logos endiathetos*, reason) and expressed in speech (*logos prophorikos*)' (New Bible Dictionary 1982).

> (1) Fundamental to everything is Meaning. It is closely connected with what we call 'God', and indeed Meaning and God are virtually identical. (2) To say God was in the beginning is to say that Meaning was in the beginning. (3) All things were made meaningful, and there was nothing made that was meaningless. (4) Life is the drive toward Meaning, and life has emerged into self-conscious humanity, as the (finite) bearer and recipient of Meaning. (5) And meaning shines out through the threat of absurdity, for absurdity has not overwhelmed it. (9) Every human being has a share in Meaning, whose true light was coming into the world. (10) Meaning was there and embodying itself in the world, yet the world has not recognized the Meaning, (11) and even humanity, the bearer of Meaning, has rejected it. (12) But those who have received it and believed in it have been enabled to become children of God.

In order to link up again with the information-issue, we can look at the ordinary sense of the conveying of meaning which actually starts with the input of 'information' (Peacocke1993:298). Peacocke (:298) quotes the work of John Bowker who talks of the role of the brain in decoding the incoming signals and representing them as information. Meaning does not lie in the quantitative information input (the counting information), but in the brain's qualitative selection out of this information. Bowker sees this as a possible basis for talking about how the presence of God can be mediated 'through the process of brain behaviour by which any human being becomes an informed subject' and, in the case of Jesus, the incarnate *Logos*, 'a wholly God-informed subject' (as quoted by Peacocke 1993:298-299). This is a bold move from trying to frame a philosophical and theological concept in scientific terms, to actually trying to explain how God could act using information input. Most of the discussions in the science-dialogue remain on safer ground!

Another example of a bold formulation is that of John Puddefoot (1992:9), who views it as remarkable that the biblical authors placed so much emphasis on the creative Word. He views the Word as the 'creative agency of God's being' and constructs the following chain of relationships:

> Word involves information. Information involves creative power. Because we can use language we can organize information to change the world in which we live. Word is the beginning of all things. The *imago Dei* in man has much to do with this capacity for language; he *speaks* and it is done.
>
> Puddefoot (1992:10)

The last word on *logos* should perhaps go to Ian Barbour (2000:61), who has noted the prevalence of models of God as the communicator of information[93], and the connection between this idea and 'the biblical idea of the divine Word [which] can be viewed as the communication of rational structure and meaning when the world is interpreted in a wider context'.

We now turn to a process perspective on God's action in the world.

5.6.6 A process perspective

God's relation to the world is quite different from a process perspective, as we have seen in our discussion of John Haught's work[94]. If the world is seen as an unfinished process in which God participates by 'luring' it towards the future, then we are far removed from the 'God-in-control' picture in which God imposes a design.

To Haught, the notion of intelligent design is 'too lifeless to capture the dynamic and even disturbing way in which the God of biblical religion interacts with the world' (Haught 2000:36). Instead of inputs of design information every now and then as Dembski[95] has it, this God is active all the time as the source of the 'informational input' that enters into each present from the future (:144). Haught's 'metaphysics of the future' is accompanied by a God who creates out of the future (:96).

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[93] Barbour (:150) says that the theological models of God in the Bible include the model of God as a communicator 'expressing meaning and rational structure through the divine Word'. See also Barbour (2000:111).

[94] In Section 5.3: *Enriching our Concept of God.*

[95] Dembski's work is discussed in Section 4.4: *William Dembski - Intelligent Design.*

As discussed previously, Haught (2000:76-80) uses the concept of Tao to try to show that information works through active inaction or non-interfering effectiveness which provides structure and pattern to the universe without interrupting in any way the unbroken continuum of events. Haught (:79) points out that Christian faith also intuits that God creates and acts via 'the manner of humble self-restraint rather than crude intervention'. The coming of Christ is the event that has shown the self-emptying or *kenosis* of a God whose effectiveness lies in the opening up of the world to a new future (:110).

Haught (2000:98) tries to explain how this action of God can take place by referring to complex physical systems that are physically deterministic and show chaotic behaviour, yet 'unfold in time almost as if they "know" where they are going"'. Haught (:98) postulates that the future states of the system 'exercise a quietly formative effect on them in every moment of their evolution, shaping their trajectories *in absentia*, as it were'. This is yet another way of articulating the idea of information input from the future. This action of God may be so subtle that science does not notice it due to its orientation towards the temporal past. One needs to be open to the power of the future in order to perceive this action. Haught (:98) links this openness with the message of prophetic theology, namely that the dreams of the faithful are not illusions but intimations of the true reality.

Of course, not only conscious beings but also inanimate matter needs to be able to respond to God. Haught (2000:166) follows Whitehead by ascribing to the fundamental building blocks of the universe a measure of feeling that 'would allow them to respond to the persuasive presence of God' which is the lure of a source of order and novelty. The cosmos could only respond to the informational possibilities 'proposed to it by God' if it had a 'subjective capacity to experience and respond to the pull of these possibilities' (:167). The world as seen through the eyes of science has been emptied of its subjective capacity to respond to God (:177).

To summarise Haught's view: he sees a God who humbly withdraws into the future, allowing a large degree of autonomy to the world, but does not withdraw completely, rather sustaining the world by offering it a range of relevant new possibilities

(2000:119). This is a kenotic God who does not enforce a divine plan, but presents opportunities.

We have now looked at the various ways in which people have used information concepts to try to understand God's interaction with the world. Our scientific understanding of the world is growing all the time and hence we need to take notice of some of the more radical recent developments in order to see whether new possibilities have arisen for developing new perspectives on God.

5.6.7 The interconnectedness of it all – recent developments in our understanding of reality

5.6.7.1 Introduction

In the introduction to this dissertation, we referred to the view that we are now living in the computer/information era in which information is the current metaphor of choice for the scientific world-view (Siegfried, 2000:45). We also referred to the fact that the concept of information has emerged as a very important fundamental way of connecting quantum mechanics, computational theory, complexity theory and evolution. In this section we will take a quick tour through these issues in order to point out just how radical this new view of the world is.

According to Tom Siegfried (2000:240), there are 'two lines of thought that provide the richest source of speculation' regarding the idea of information as a fundamental quantity, namely Rolf Landauer's principle and John Wheeler's slogan of 'It from Bit'. We will now discuss these two lines of thought.

5.6.7.2 Landauer's principle

Landauer studied the physics of computing and showed that computing 'in and of itself did not require any minimum use of energy', in other words an ideal computing system would not waste heat at all (Siegfried 2000:70-71). The problem was that *erasing* information required energy. Landauer calculated that erasing a single bit of information led to an energy loss roughly equivalent to the energy of a bouncing molecule (:71). This can be visualised as follows: Imagine that you are standing on a floor with a ball in your hand and a ball at your feet. This represents a system with two states, 1 and 0. The ball in your hand represents (1), the ball at your feet (0). In order to erase the bit, you drop the ball in your hand, but it does not occupy the zero state – it bounces back up to the 1 state, unless it loses energy via friction and deformation of the ball (as indeed it slowly does as it bounces up and down). Here we have the fundamental connection between energy and information. The fact that erasing a bit of information requires a minimum energy loss is known as Landauer's principle (:72). Further work by Charles Bennett showed that one could in fact compute without using energy if one never erased information (:73). This type of computing did not involve storing an infinite amount of information, but one had to ensure that the computing was reversible, it had to be possible to retrace all the computational steps so that any previously generated information could be reconstructed (:73).

Well, where does this lead to? Landauer has made a startling connection between his principle and the laws of physics. He views the laws of physics as 'recipes for performing computations' (Siegfried 2000:241). Scientists use these laws to calculate in advance what will happen and the question is: What would these laws actually mean if we could not actually do these calculations? Information processing and physical laws 'must in principle be tightly entangled' (:241). The ultimate laws 'must be limited to what actually can, in principle, be calculated in the universe we inhabit' (:241). We cannot do an infinite number of calculations based on our laws, and hence these laws must be idealisations, the 'real' laws must be limited by the universe's ability to support these calculations (:242). We will see in the next section where this argument can lead to with regard to our understanding of the situation at the origin of the universe.

5.6.7.3 Wheeler's 'It from Bit'

John Wheeler has expressed the same thoughts, but in a different way. He does not believe in the actual existence of a continuum of numbers (Siegfried 2000:245). One cannot go on *ad infinitum* with the process of finding another number between two numbers. Wheeler's slogan, 'It from Bit', deals with the fundamental nature of the quantum world:

> *It from bit* symbolizes the idea that every item of the physical world has at bottom - a very deep bottom, in most instances - an immaterial source and explanation; that what we call reality arises in the last analysis from the posing of Yes-No questions and the registering of equipment-evoked responses; in short, that things physical are information-theoretic in origin.
>
> [my italics](as quoted by Siegfried 2000:245)

The example Wheeler uses is that of a photon-detector picking up a photon that has travelled from a source to the detector (Siegfried 2000:245). If we ask whether the detector clicked during a certain interval, and the reply is Yes, we usually say that a photon was the cause. So we normally imply that a photon existed. We do not talk of the photon as if it exists before the emission or after the detection. Can we, however, talk of the photon as if it exists between these two events? Wheeler calls any talk of the existence of the photon as a 'blown-up version of the raw fact, a count' (:245). The photon detector count is the answer to the question we posed originally. All that we can know is one bit, the answer to a Yes-No question (:246).

Another example of the consequences of the physical nature of information is the intriguing fact that the surface area of black holes increases as information falls into them (Siegfried 2000:246). When a massive star explodes at the end of its lifetime, the residue is a massive core that collapses due to gravitational attraction. The gravitational forces are then so intense that nothing, not even light, can escape from falling into it, hence the term 'black hole'. Since any object of any kind contains information due to the fact that its structure contains information about the way the parts are related, information is lost forever when an object falls into a black hole (:197). This creates a problem since the laws of quantum physics specify that information is never lost; in principle one must be able 'to trace back everything that has happened' in the past (:197). Here we have a link between quantum physics and gravity, the fundamental building blocks of our understanding of reality. Wheeler found that as a black hole swallows information, its surface area increases accordingly. The increase in surface area is due to the increase in the entropy (or degree of disorder) of the black hole, which increases its size and hence its surface area (:200). The paradox of the destruction of information by black holes remain unresolved. Siegfried (:205) says that 'here in black holes, at the intersection of gravity and quantum mechanics, was another instance of information playing a central role at the scientific frontier'. Scientist Chris Fuchs has applied Landauer's principle to analyse the erasure of information by black holes (:205). The erasure of information requires energy and consuming energy increases the entropy. This leads to an increase in the surface area of the black hole. The relationship between the destruction of bits and the increase in the surface area can be calculated, and it agrees fairly well with other ways of determining the effect of entropy-increase on the surface area (:206). This confirms that Landauer's principle, devised in the realm of computers, is also applicable to astrophysics (:206). To Siegfried (:206), this suggests that the notion that information is physical, as explicated through the development of the physics of information and computation, may 'offer important insights' into the development of a theory of quantum gravity that reconciles quantum mechanics with general relativity. John Wheeler predicts that in future 'we will have learned to understand and express all of physics in the language of information' (as quoted by Siegfried 2000:246).

5.6.7.4 The universe as a computer

Edward Fredkin is another scientist who, like John Wheeler, has tried to work through the consequences of posing the question regarding the actual existence of a continuum of numbers (Siegfried 2000:57-59, Brown 2000:58-60). Fredkin is famous for the idea that the universe is a 'gigantic digital computer processing information' (Brown 2000:59). To Fredkin, 'information processing is at the foundation of everything that happens' (Siegfried 2000:58). Whereas traditional dynamics would describe the world in terms of matter in motion, with the associated momentum[96] being the property that is conserved, Fredkin holds instead that momentum is nothing but information. 'It's the information that tells a particle at one point in space and time where it should be at the next moment' and this next moment arrives due to a

[96] Momentum = mass x velocity.

computation that 'transforms information from the present into the new conditions representing the next instant of time' (:58-59).

Where does this thinking come from? Quantum mechanics has shown that energy and many properties of matter are quantised. This has led Fredkin to postulate that *everything* is quantised: space, time and all properties of matter come in indivisible units so that nothing is continuous (Brown 2000:59). The benefit of this idea is that it places a ceiling on the amount of information in the universe. If aspects of nature were continuous, nature would contain an infinite amount of information. This universe in which everything is quantised is thus 'analogous to a digital computer because, in both, everything would be discrete and finite' (:59). Now we come to the crux of the argument where the different elements come together. As Brown (:59) says of the state of knowledge in the 1950s when Fredkin did this work:

> If the universe was a gigantic digital computer, the laws of physics had to be part of the computer's program. It was known that the laws of physics at a microscopic level were reversible, yet all known computers were irreversible.

We have mentioned Landauer's principle and Bennet's work which lead to the possibility of reversible computing without any energy consumption. Fredkin used a different approach, by developing the Fredkin logic gate[97]. This works reversibly, enabling the construction of a reversible computer (Brown 2000:61). A complete design for such a computer has been developed (:71). The next step is to make explicit the assumption that physics and computation are alike by actually building an artificial universe. The machines known as 'cellular automata' allow one to do exactly this (:71).

[97] Computers are based on binary logic (true = 1, false = 0). Any binary logic circuit can be built up by connecting a selection of AND, OR and NOT gates. An AND gate takes two inputs (e.g. 0 and 1) and produces one output (in this case a 0, since 0 is not the same as 1 and hence 0 **and** 1 = 0). In order not to lose information, a Fredkin gate has the same number of outputs as inputs (Brown 2000:61-62).

5.6.7.5 Cellular automata

The idea of a cellular automaton (CA) was developed by John von Neumann in order to show how artificial forms of life could be produced by means of computers (Brown 2000:72). Self-producing machines were a key notion. Von Neumann came up with the idea of 'beings' that lived on a two-dimensional grid, where each square or 'cell' was programmed to follow mathematical rules that determine whether they live or die or reproduce (:72). John Conway developed a version called the Game of Life, which has been implemented in many freely available software programs. Computer scientists and mathematicians have used cellular automata as a 'powerful tool for studying how complexity can naturally arise from very simple laws' (:73). Cellular automata can not only perform universal computation[98], but they can also work reversibly (:73). Fredkin is fascinated by CAs. He regards them as the most natural model for the view that the universe is a computer since they share three properties with the physical world (:73-74). CA's computations are local, occur in parallel, are reversible, and the rules are the same everywhere. Likewise, the laws of physics are also the same anywhere, are reversible, and the computations of physics are also local and in parallel. Tom Toffoli and Norman Margolus, by changing the rules of CAs, have used them as a way of modelling physics in artificial universes (:75). They have called their CAs the 'God Game' because they can play God with this artificial universe (:75). The connection between CAs and physics works both ways: physics can be described as a computational process and computation is physical (:76). It remains somewhat of a leap to take the next step to describe all of nature, and not just physics, as a computational process. Although Toffoli and Margolus do not follow Fredkin in saying that the universe is a computer, Toffoli has described nature as having been 'continually computing the "next state" of the universe for billions of years' (as quoted by Brown 2000:76). Margolus has made calculations of the number of computations going on in a piece of matter (:76). This depends on the amount of energy and for each joule of energy, an astounding maximum processing rate of approximately 10^{33} operations per second is calculated (:76). Fredkin has calculated the total amount of computation occurring in the universe by determining the size of a CA needed to simulate the universe in all its details. The answer is astonishingly

[98] Alan Turing showed that computers are 'universal in the sense that any one computer can do the same thing as any other' (Brown 2000:61).

small: a CA operating at the smallest possible quantum scale would only need to be the size of a fairly large star to 'faithfully simulate the entire macroscopic evolution of our universe from the Big Bang to the present in about four hours' (:76-77). Fredkin calls the difference of 10^{63} in space-time volume between the universe and such a system, the 'missing workload', which thus forms one of the great mysteries of the cosmos (:77). Fredkin's explanation for this is that 'either something else is going on in the universe that we don't know about or God was incompetent on a scale that boggles the mind' (as quoted by Brown 2000:77). My position is that we just do not know what is really going on! The size of the 'missing workload' shows how little we understand.

We will now briefly examine some of the other ways in which the impact of information concepts has been pervasive in all fields of science. Siegfried (2000:240) talks of an 'information-computer approach to science', which has grown from within science, leading to explorations by scientists such as 'biologists untangling the inner action of cells and neuroscientists analyzing the brain to physicists teleporting photons and building quantum computers', and all of these explorations have information as a 'tangible commodity' at their cores.

5.6.7.6 Cells

We start at the cell. In Chapter 4 on Gitt's work we have covered the information-storage aspect of DNA and the encoding role that DNA plays in the production of proteins. Leonard Adleman has been the pioneer in demonstrating that DNA can compute[99] and in fostering the model that the living cell is a programming system, 'an information processor extraordinaire' (Siegfried 2000:97). Laura Landweber describes evolution as 'having years to compute solutions to all sorts of problems' such as 'what is the best approach for the reproductive success of the species'. (:101). Evolution produces competing algorithms.

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[99] See Gitt's discussion of genetic algorithms in Subsection 4.2.6.2 as well. Adleman was the first to use DNA in this way to do parallel computation (Siegfried 2000:111-112).

If DNA is the hard disk, then proteins can be viewed as the RAM[100] where most of the computing action takes place (Siegfried 2000:104). The cell's chemistry represents a computer's current memory state since 'protein activity changes constantly with new inputs of outside information into the cell' (:105). Bacteria 'know' how to swim towards food since circuits of proteins, which are responsive to the environment, control the swimming. The messages from outside the cell arrive in the form of molecules that are locked onto by receptor proteins in the cell membrane. The part of the receptor protein that is inside the cell changes shape, which causes other proteins inside the cells to change shape as well, thus triggering a chain of chemical reactions that determine the behaviour of the cell (:107). This is a beautiful example of the *physical* nature of information and, as Schmitz-Moormann has discussed[101], there is no separation of information and its structure - the shape (information in the relations of the atoms) of the 'signal' molecule fits into the docking-area of the receptor protein and then the shape of the receptor changes - a real example of shaping information in action! The cell computes output from input just like any other computer. In a similar manner, the immune system can be viewed as processing information about invading organisms (:110). We can now move up the ladder of complexity to the most complex biological information processor, the brain.

5.6.7.7 The brain

While there is general agreement amongst neuroscientists that the brain computes, one should not confuse the brain with a computer. Ira Black, a neuroscientist, pointed out that computers and brains both process information by manipulating symbols. In computers the 'symbols are electronic patterns', whereas in brains, 'the symbols are molecules' (Siegfried 2000:120). The key difference is that there is no distinction between hardware and software in the brain since 'molecules are both the symbols representing information in the brain and the tools that perform the brain's tasks' and therefore hardware and software are the same (:120-121). In a computer, the hardware is idle unless activated by the software program. The brain is a 'flexible and complicated chemical factory, constantly reorganizing itself in the light of new

[100] Random Access Memory - for example your Personal Computer's volatile memory.

[101] See Section 5.5: *Linking the hierarchy of organisational levels*.

experiences', and not a hard-wired machine like a computer. An experience induces chemical changes that can last from days to weeks. Black asserts that human behaviour can ultimately be seen as being the output of all the molecular messaging happening in the brain (:121). Brain processes are part of a chemical loop that connects genes and environment, and notions such as 'mind' or 'self' should emerge naturally from understanding the loop (:121). The gap between molecular messaging and behaviour can, in principle, be bridged as Black asserts, but it will be a long bridge-building exercise in which information processing and the new field of study called 'computational neuroscience' will probably play a role (:121).

5.6.7.8 Computational neuroscience

Computational neuroscience uses computers to make models of neurons and then uses these models to study how neurons compute (Siegfried 2000:121-122). Ultimately, the goal is to study how the brain's nerve cells combine to create thoughts and behaviour. Neurons are linked into networks and, similarly, artificial neurons are linked to each other, forming what is called 'neural networks'. Typically, the neural network would assume that neurons are either on or off, depending on the inputs received from the neurons it is connected to. Computational neuroscientists try to simulate real neurons in which each neuron's output depends on the influx of many different messages, and neurons are not actually on or off, but have different rates of firing of electrical impulses (:123). The complexity of the brain is becoming clear. A 'whole ladder of understanding' is required which starts at the level below neurons, the messenger molecules and the protein molecules of the cell membranes, continues up to the cell level, then to how cells are connected via synapses, and then we have the small networks of neurons that form, finally, subsystems of networks forming the central nervous system (:123). In order to get to behaviour, the whole ladder must be simulated. We are now still pretty much at the level of the single neuron and here progress has been made in understanding how changes in the cell itself can also affect behaviour (:123, 127-128).

Apart from the fact that we are still at very basic levels of understanding about the brain, there are still disagreements about whether the brain is like a computer or not, with Roger Penrose[102] and John Searle[103] being prominent denunciators of this idea. We will not cover their arguments here, but will focus on the interesting debate as to what sort of physical mechanism at work: Is the brain like a computational mechanism or a dynamic mechanism? (Siegfried 2000:130). This question is also linked to chaos and complexity theory.

We have discussed previously[104] the popular notion that thinking, like computers, deals with information and that thought is therefore the manipulation of symbols that represent information (Siegfried 2000:131). The dynamic view is that 'the mind's powers stem not from mimicking microprocessors, but from the natural processes of molecules in motion' (:130). Thought is therefore an aspect of nature like any other, and can be described by equations similar to that governing the motion of the particles in a system, e.g. the planets in the solar system. Many particles make for a complex dynamic system, such as the weather. The key issue is then whether thought is 'merely the result of matter in motion, or is it a process of representing and manipulating information?' (:131).

It may be that both points of view are true in part. The brain is made up of cells, which are made of atoms, which are constrained to obey the laws of motion. If the brain is a dynamic system, its condition will change as the particles move according to the laws of motion and this may in some way determine our behaviour (Siegfried 2000:138). Dynamics emphasize the way a system's parts *change* with time, whereas the computing view focuses on the *arrangement* of the system's parts at any given point in time (:138). This arrangement is a structure that *represents* information. Sensor signals enter the brain and change its pattern (neurons firing) to form a new structure, and thus input is transformed into output (:139). Melanie Mitchell of the Sante Fe Institute in New Mexico has argued that both dynamic and computational

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[102] Penrose put his case that the brain is not a computer, since it can do what no Turing machine can do, in the following two books: *The Emperor's New Mind* and *Shadows of the Mind* (Siegfried 2000:126-127).

[103] John Searle has developed the Chinese room argument which tries to show that people understand what they do whereas computers do not (Siegfried 2000:127-129). An overview of this argument is given in Subsection 4.4.5: *The complexity-specification criterion in action*.

[104] When we discussed Ira Black's position regarding the brain in this section.

theories are required to explain thought and that a theory is needed that incorporates both change and structure (:139). The seeds of such a theory could be found in the work done on theories of complexity which attempts to explain how complex behaviour can emerge from systems with large numbers of interactions between fairly simple constituents. Jim Crutchfield, also of Sante Fe, does not think that the issue is whether the brain is dynamic or computes, but rather how the dynamic system (that is the brain) performs the computations (:140). Mitchell has found that processes that appear to be dynamic, 'like particles in motion, can perform the task of representing and conveying information' (:140). He has demonstrated this through the use of cellular automata as an example of a device that can learn to compute without receiving any instructions from the outside (:141-143). Each cell receives its instructions from its neighbours, based on the rules that are set up, and there is no central control. Such a system has been shown to perform a computation leading to a desired behaviour, e.g. half the cells on and the other half off, and the step-by-step progress of the system has revealed a 'pattern of activity that looks very much like the plot of particle paths in a dynamical system' (:142). Mitchell says that the particles 'move in such a way as to allow the system to compress information about the environment and to communicate information throughout the system' (:142). In order to find the local rules that will lead to the desired end-result of a certain type of global co-ordination, the techniques of genetic and evolutionary programming[105] are followed. Strings of computer code that encode the various local rules are allowed to mix and combine at random, with the most successful rules being allowed to produce the next generation. After many generations, the most successful rules emerge with the ability to solve the desired problem and hence the system of cellular automata has essentially produced its own program.

The importance of this work is that it provides a means of understanding how sophisticated behaviour such as thinking can emerge when simple things such as neurons process information (Siegfried 2000:143). Ultimately, Mitchell suspects that this understanding will help bridge the gap between inanimate machines and living entities, as our understanding of what a machine is and what life is changes. Our

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[105] See also Gitt's arguments against the significance of these techniques in Subsections 4.2.6.1 and 4.6.2.2, as well as Subsection 5.2.2.4 for Smith's view.

notion of a machine becomes more biological and our notion of biology becomes more machine-like.

This concludes our brief glance at computational neuroscience in which we have tried to show how it could play a role in bridging the gap between molecular messaging and behaviour to which Ira Black has referred. We have also reinforced the point that the distinction between hardware and software is moot in systems such as cellular automata, which produce their own programs through an evolutionary process. Therefore, unlike our standard computers, this type of computer has much more in common with the brain, in which there is no distinction between hardware and software. The other point is that these computers are very different in terms of their architecture, since they do not have a central controller as do ordinary computers, but a collection of simple elements connected in complicated ways, just like the brain. The intelligence of such systems can also evolve. We have therefore started to address the mystery of how living things can compute, which probably forms the basis of intelligence.

5.6.7.9 Consciousness, observers and complexity

We have not yet touched on the mystery of consciousness. This is really at the frontline of research, indeed it is probably the final frontier. It is not clear which approach would be the best to understanding consciousness, but it is probably safe to agree with Siegfried (2000:148) that insight into information processing will be central. We will briefly mention a few examples of one type of approach that links back to the fact that information is a fundamental part of reality.

David Chalmers, in the context of investigating consciousness, dismisses materialism and functionalism, and proposes a two-aspect theory, which he calls 'property dualism' or a form of panpsychism (Barbour 2000:145). In this theory, information states, which are realised both subjectively and physically, are the fundamental building blocks of reality[106]. 'We might say that the internal aspects of these states are

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[106] In essence, his theory of consciousness posits the existence of information as a new fundamental property (Horgan 1999:242).

phenomenal and the external aspects are physical. Or as a slogan: Experience is information from the inside; physics is information from the outside' (Chalmers as quoted by Barbour 2000:145).

Another approach has been to combine quantum physics and information processing via the notion of observers (Siegfried 2000:160). If information is a fundamental part of reality, and observers are the entities that gather information, then they must play some role. Just what the role of the observer is, has been the subject of much debate in quantum physics. Barbour (2000:80) holds that it is not the mind that affects observations but the actual interaction between the measuring instruments and the system. Information becomes available through this interaction. Barbour (:80) states: 'The transfer of information, not consciousness, is the essential feature of the "collapse of the wave function" during an observation'. This is another way of formulating the essential role of information in all interactions of matter at the quantum level.

In agreement with this approach and in contrast to the view that observers are 'some sort of magicians pulling reality rabbits out of a quantum hat', a new focus has been placed on the role of observers as entities that 'acquire and process information', or so-called IGUS (Information Gathering and Using Systems) (Siegfried 2000:160).

There is a natural connection between complexity, information processing and observers. The understanding of complexity involves information-processing ideas and information processing naturally involves the idea of observers (Siegfried 2000:161). Murray Gell-Mann has outlined a way to understand complexity (:161-166). One starts out by considering the level of detail that one wants to describe and then specifies the sort of language one wants to use to describe the system to somebody else. The degree of complexity of a system is then related to the length of the shortest message required to describe it. 'Shortest' in this context means the shortest computer program needed to produce this description of the system. Gell-Mann called this the 'ideal complexity' (:162). We have often met this notion of complexity commonly called algorithmic complexity[107]. Basically, the issue is that a string of a hundred 1111111111's can be reproduced by the program 'Print 1 a 100 times', which is a whole lot shorter yet expresses the same information. The ability to shorten or compress the message describing a system is the key to understanding the nature of observers (:163). This is a non-mystical view of observers. Observers are seen as being simply the complex systems (human, non-human, non-living) that have the ability to compress information about the environment. Not all complex systems can compress data. The special ones that can are called 'complex adaptive systems' by Gell-Mann and they can adapt and evolve (:163). According to this definition, people, and all other living things, are complex adaptive systems, as are some products of living things such as human language, the economy and the enterprise of science (:163-164). Complex systems such as thunderstorms are not adaptive since they do not compress information as living things do in their DNA. Another key property of adaptive systems is their ability to process and compress information to generate a *schema* that 'encodes a system's experience of the environment into principles that summarize the regularities of nature' (:164). This schema provides a representation of how nature behaves. It describes the regularities of nature and allows the organism to adapt to these regularities. Here again we come up against the issue of randomness. A truly random message cannot be compressed and hence will have an equally long computer program to represent it. The complex adaptive system must have the ability to develop a schema that compresses the regularities and discards the random inputs that reduce the system's ability to predict the results of actions. Systems with the best schemas will survive because they can predict correctly what will happen. Gell-Mann's view is that a similar process underlies the undertaking of science as well, with scientists encoding the regularities they discover into a schema or set of theories.

[107] See definitions in Subsection 2.1.3. Algorithmic complexity is also called the Kolgomorov complexity. Kolgomorov showed how a deterministic device (a Turing machine, a universal computer) could manufacture randomness (Siegfried 2000:169). According to Jim Crutchfield, this notion of complexity is actually the same as Shannon's idea of information produced by a source (:169). We have discussed Davies' use of this concept in Sections 4.3.4 and 4.3.5 and Dembski's use of it in the context of Complex Specified Information in Section 4.4.7.

The best measure of complexity is then not just the length of the shortest computer program, but the length of a schema needed to describe a system (remember that a schema excludes the random elements) (Siegfried 2000:166). Gell-Mann also considers the amount of effort it took to produce the schema, as in how much time scientists took to produce the theories. This quantity Gell-Mann calls 'depth' and it reflects 'the number of steps in the process leading from a system's origin to its current state of complexity' (:166).

It should be clear that we have arrived at a measure that also reflects information content and not information quantity, which is dominated by randomness. The move from algorithmic complexity to the schema is a crucial one since it is the move from information as quantity as per Shannon's definition, or counting information as we have called it, to information as content. Another approach to content information is that of Jim Crutchfield who has developed the concept of complexity as structure, as the non-random stuff of a system. He calls his notion of structural complexity 'statistical complexity' (Siegfried 2000:169). The statistical complexity is low when the randomness is high and it is low when the randomness is low. In the intermediate range where randomness and complexity are mixed, statistical complexity is high. This tallies with 'depth' since if the system is either very simple or very random, one will not take a lot of time to figure it out. The technical definition of statistical complexity is that 'it measures how much memory you need to record enough information about the system to predict what it will do next' (:170). So if a system's behaviour is very regular, a few measurements will enable accurate prediction. If a system's behaviour is random, then one will soon realise that and will not need to store information about it since we cannot predict its behaviour in any case. More complex systems will produce behaviour that takes longer to understand, is more structured and will require more memory to describe and predict. The important point here is that when complexity is measured in this way, it is 'in the eye of the beholder, or the observer or the IGUS' since statistical complexity measures the ability of an observer to predict its environment (:170-171). Thus we are now starting to measure something that is meaningful to the observer. We are moving towards understanding what information means to some entity. Statistical complexity and its associated information measure are starting to bridge the gap between counting information and meaning information.

Things get really interesting when we examine the *interactions* between these observers. Crutchfield talks of these observers as 'agents'. They are complex adaptive systems which survive by observing their environment, representing the regularities thereof in their memories (a schema) and acting accordingly (Siegfried 2000:171). Part of their environment is the other agents and they need to figure out each other's behaviour in order to be able to predict (compute!) and act accordingly for survival. Those that are smarter, with better schemas for recording the environment and better abilities to process that information in order to choose the best actions, will survive better. This, then, provides a new way of looking at evolution as involving agents and computing resources. Crutchfield calls it 'evolutionary mechanics' and it can explain how new species emerge (:172). Crutchfield's model as described by Siegfried is given below:

> In his view the universe is a deterministic dynamical system, its parts all moving according to natural law and the forces that act on them. Agents within this universe do not appear to be deterministic, though, to any agent observing them. That's because the observing agent has limited resources to make a model or schema of other agents. Since one agent cannot predict everything about another agent, some of that other agent's actions seem random. With more computational resources, an agent could predict more about another agent's actions and therefore choose wiser behaviours in response. An agent's model of the jungle, after all, controls how the agent will behave in response to various sensory inputs.
>
> (Siegfried 2000:172-173)

New features of life can emerge as agents adapt by improving their ability to process information. There is a trade-off: if resources are plentiful, agents can develop more sophisticated models and store more information about the environment, whereas if resources are scarce, agents with simpler models have the edge since they require fewer resources. Therefore relatively simple agents such as flies find a niche in a complex world together with complex agents such as human beings. From an 'information-processing' perspective, the different species develop through 'innovation', in which an agent learns to make a more efficient model of its environment using its limited resources, thus becoming a new agent (Siegfried 2000:173). At the core of Crutchfield's views is the realisation that 'reality is a process' that 'balances stability and order against instability and change (:173-174). Crutchfield also quotes Whitehead: 'The art of progress is to preserve order amid change'[108] (:174). In Crutchfield's conception of the universe of 'computational agents, information storage assures stability and order; information processing permits instability and change' and therefore computation is the 'paradigm of reality as a process' (:174).

The other fundamental issue that arises out of Crutchfield's conception of the universe is that the regularity observed in the universe depends on the ability of the observer to describe and compute, and hence the regularity is not simply out there to be discovered (Siegfried 2000:174). Agents 'bootstrap' themselves up on the basis of what works, not necessarily dealing with the full complexity of what is out there. Siegfried makes the observation that science is the way that we use to describe the universe, and since humans do not have infinite resources, our description of the universe will also not be omniscient. We do, however, improve as scientific revolutions occur (driven by better use of resources and the discovery of additional resources, e.g. computers) that radically change our schemas of the universe. Ultimately, our understanding is limited by ourselves, the observer describes reality. The link can also be made to the quantum mechanical description of the world. Gell-Mann, for example, sees the role of the observer as being the something that is betting on the probabilities, which I interpret as making one of the many possibilities real (:175).

After our quick survey, it is now time to take stock and speculate about what all of this means in the context of trying to understand divine action.

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[108] We discussed God's relation to the world from a process perspective in Section 5.6.6. Process theology is also discussed in more detail in Section 6.2.5. We can just note here that process philosophy sees the basic components of reality as 'not the two kinds of enduring substance (mind and matter), or one kind (matter), but *one kind of event with two aspects or phases*' [Barbour's italics] (Barbour 2000:146).

5.6.8 Applying our information-based understanding of reality to the issue of divine action

5.6.8.1 Introduction

There are a few key speculations about the nature of reality that can have a major impact on how we think about divine action. We will discuss the possible impact of the linkage between laws, matter and information, and take a look at what CAs teach us about control.

5.6.8.2 Laws, computation and matter

We have discussed Rolf Landauer's work in computational physics. One of the fundamental linkages that he talks about is the limitation placed on the laws of physics by the universe's ability to support computation. This leads him to a new understanding of the laws of physics. Landauer says that the standard view of the laws of nature is deeply ingrained in our culture and uses the Bible as an example (Siegfried 2000:244). Landauer interprets 'In the beginning was the Word' as meaning that 'in the beginning the controlling principle of the universe was present from the outset' (:244). According to him, this means that 'the laws of physics preceded existence itself', but his opinion is that 'the controlling principle must be expressed within the physical features of the universe' and hence existence comes first and then the laws (:244). Landauer is joined in this by John Wheeler who uses the slogan 'law without law', and does not think that the laws of physics are 'eternal and immutable', but that they are 'like species, mutable and of "higgledy-piggledy" origin' (as quoted by Siegfried 2000:245).

This does leave us with food for thought if our conception of God's action is that of the law-giver for the universe and as the continual sustainer of the law. The laws guiding the universe's behaviour may arise out of the interaction of matter itself, which of itself is doing computation all the time. We can sketch a radical progression from a singularity of compressed matter to dispersed matter that forms structure, information in the relations within the structure itself. The structure is formed under the guidance of laws that can be viewed as being of the nature of information processing by the matter involved. If we take seriously Landauer's thinking that the

'the controlling principle must be expressed within the physical features of the universe', then we move towards a picture of God, not as the distant or initial law-giver of deism, but as an immanent God, as the controlling principle. John Haught formulated the same kind of idea. Haught (2000:76) views informational patterning as 'a metaphysical necessity; for in order for anything to be actual at all, it must have at least some degree of form, order or pattern'. We can view God as being the immanent source of the pattern, out of which flows reality. God's action is then non-interventionist but essential. When we now bring in Wheeler's idea that all things physical have at source an immaterial, information-theoretic origin, then we are really sailing in some very deep waters of metaphysics. Perhaps we should be provocative and state that we should talk of 'information' instead of metaphysics, since 'information' is now coming to the fore as that which is really beyond physics.

We have been discussing what could be called the ultimate form of local control. We now turn to CAs and the lessons learned about control and top-down effects.

5.6.8.3 What CAs teach us about control

CAs show us that complexity can arise from very simple laws, and that local computational intelligence in fairly simple entities can evolve and combine to achieve global co-ordination so that the system as a whole responds appropriately to the environment. Our idea of a computer with hardware and software as distinct entities is being replaced by that of a network of CAs developing their own programs as they evolve as a result of inputs and constraints from the environment. The thinking done by Peacocke and Polkinghorne on the concept of active information[109] is relevant here. The interaction between CAs and the environment may be the best way we currently have of understanding Polkinghorne's 'top-down causation' via an 'an ontological influence of context on behaviour' (Polkinghorne 1995:107) or what Peacocke (1995:115) calls 'whole-part constraint' via boundary conditions and high-level processes. CAs show us that intelligence can evolve in reaction to the environment based on simple building blocks evolving simple laws regarding their local interactions. CAs have an interesting combination of local control, co-ordinated

[109] See Subsection 5.6.4: *Active information*.

behaviour and environmental influence. God can be immanent, part of the essence of what each cell of a CA is, and God, by being immanent in everything, is also part of the environment and hence also exerts an influence on the intelligence that is evolving.

The outcome of this seems to be that rather than a God-of-the-gaps, we can talk of a God who forms the fitness landscape, creating laws and an environment that is 'informed', shaped with direction. Just as life is not a property of single molecules, and CAs are only intelligent as part of the network, so God's creative actions cannot be discerned by studying the bits and pieces of the cosmos, but are a property of the cosmos as a whole. God's guiding influence can possibly be regarded as operating via the setting of the boundary conditions, the informational patterning of reality, the design of the fabric of reality, and via the design of the embedded constraints, such as the quantisation of everything.

6 It is all a matter of interpretation and points of departure

6.1 Introduction

As an example of different points of departure, we can briefly discuss the reaction of Robert Russell to Dembski's attack on Darwin's theory of evolution. As we have noted in the discussion of Dembski' approach, Robert Russell's (1998:192-193) approach is that 'theistic evolution offers the real attack on atheism by successfully giving a Christian interpretation to science - thus undermining the very assumption they share with atheists, namely, that a Darwinian account of biological evolution is inherently atheistic'. This, then, is in contrast to the fundamentalist approach of an all-out attack on the results and methods of science. The underlying assumption is that the results of science are 'value-neutral' and it is the interpretation of the results that depends on one's viewpoint. An atheist such as Richard Dawkins would probably deny this since 'letting the results speak for themselves' (as if that was possible ....) suits his atheistic goals.

In trying to understand the different viewpoints and the different approaches that scientists and religious people take, it is very useful to examine the typologies developed of the ways in which people have related science and religion.

6.2 Barbour's four-fold typology of the relationship between science and religion

6.2.1 Introduction

Ian Barbour is a highly respected figure in the field of science and religion and his typology, which dates from his 1990 book *Religion in an Age of Science*, will be used as our basis. Other attempts at typologies will also be mentioned.

The four-fold typology is (Barbour 2000:2-4):

- Conflict
  - As an example: Groups that agree that you cannot believe in both God and evolution, such as biblical literalists and atheistic scientists. You have to believe in either the one or the other explanation.

- Independence
    - Science and religion refer to different domains of life or aspects of reality and they use different kinds of language that serve different functions. Science deals with the How? and religion with the Why?
    - In a weaker version, people hold that science and religion offer complementary perspectives that are not mutually exclusive. Conflict can therefore only arise when people exceed the boundaries, when science philosophises and religious people make scientific claims.
- Dialogue
    - Comparing the methods of the two fields, pointing out similarities and differences, for example, the use of conceptual models and analogies for the unobservable.
    - Science raises limit questions that it cannot answer itself (Why is there order in the universe?).
    - Using concepts from science as analogies when talking about God's relation to the world (God as the source of information?).
- Integration
    - A partnership model with different degrees of integration.
    - There are three distinct versions with different points of departure:
        - A *natural theology* seeking proof in nature of the existence of God.
            - For example, the use of the argument that physical constants appear to be fine-tuned as if by design.
            - The point of departure for the argument is science and its results, e.g. as evidence for design (:118).
        - A *theology of nature*. The reformulation of religious beliefs due to the results of science.
            - The point of departure for the argument is theology (the life of a religious community) (:118).
        - A *systematic synthesis*. Using a philosophical system to interpret both scientific and religious thought within a common conceptual framework (as in Barbour's (:28) use of process

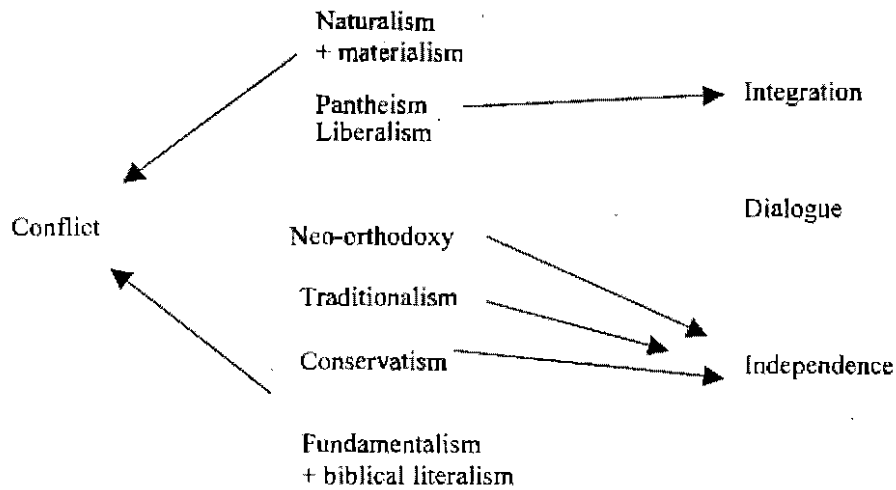
theology, in which 'both science and religion contribute to the development of an inclusive metaphysics').

- The point of departure for the argument is metaphysics, 'the search for the most general philosophical categories for interpreting diverse kinds of experience' (:118).

The very idea of a classification scheme has been criticised on the grounds that 'the relations between science and religion are too complex and too context-dependent to be grouped under any classification scheme' (:4-5). Van Huyssteen (1999:282-283) argues against rigorous demarcation between the domains of enquiry into science and religion that is implied by such models. Although the standards of rationality will be different in each domain, the resources of rationality are present in each, allowing for interdisciplinary dialogue. We can abandon attempts to unify and integrate all our discourses under a single unified form of knowledge. Rationality is present in each domain, in theology and in the sciences.

Another school of thought denies that science and religion *can* be related at all since the ideas of both science and religion are social constructions and do not describe reality at all. Therefore you cannot argue that they are both about the 'same thing' Barbour (2000:5). Barbour (:5) sees the purpose of the typology as being to function as a 'guidebook' to the interdisciplinary field. He admits that by their very nature guidebooks are selective and may oversimplify the complexity of the real world.

In the context of this dissertation, the typology is used to show the influence of the different points of departure that people have and how that affects their use of the conceptual models of science. Barbour (2000:10-11) relates what he calls the *theological spectrum* to his typology of relations between science and religion. We can represent these relationships as follows:



As we can see, the two extremes of naturalism and fundamentalism are grouped together under Conflict due to the fact that both make strong claims about nature and both demand that one chooses between them as rival versions of the truth. Independence is a position favoured by conservatism, traditionalism and neo-orthodoxy. The participants in Dialogue do not fit easily into Barbour's theological categories. Pantheism and liberalism favour Integration.

John Haught developed a typology with the categories Conflict, Contrast, Contact and Confirmation (Barbour 2000:4). Conflict and Contrast correspond to Barbour's Conflict and Independence, and Contact combines Dialogue and Integration. The category of Confirmation deals with 'the vindication by science of the background assumptions originally derived from theology', which is viewed as a form of Dialogue by Barbour (:4). There are more complicated classification schemes: Barbour (:4) mentions those of Ted Peters and Willem Drees. Barbour (:4) mentions that there is a trade-off between increased precision and the ability to accommodate a diversity of views.

We will now analyse some of the work in the area of information concepts to see if the typology sheds some light on the factors underlying the positions adopted and the resultant use of information concepts.

6.2.2 Conflict

We have covered Gitt's work and he is an example of what Barbour calls 'biblical literalism'. Dembski is a leading light of the Intelligent Design movement, which represents a shift away from biblical literalism to a more nuanced attack on the naturalists such as Dawkins. The metaphor of conflict suits both parties since both hold strong views that there is only one truth and that there is only one way to that truth.

The conflict is on the world-view level and on the level of the methods of science as well. Dembski makes it clear that his approach is two-pronged: a scientific and philosophical critique of enlightenment rationalism and scientific materialism or rationalism (Dembski 1999: 14, 120). Gitt (1997: 101) is of the opinion that scientists are vassals of materialistic philosophy and that evolution is a metaphysical research programme. Dawkins espouses epistemological reductionism and ontological reductionism or materialism (Barbour 2000: 94), in other words, there is only matter. In reaction, Gitt (1997:47) tries to show that information is another fundamental entity whose origin cannot be explained in terms of material processes.

It is interesting that the status of science is elevated by both parties. Dembski makes it quite clear that it is important to be able to detect God empirically(!) because science is the only valid form of knowledge in our culture (Dembski 1999:118). Gitt (1997:10, 79) is at pains to formulate natural laws of life that are based on empirical reality and to show how evolutionary theory violates these laws. Both Gitt and Dembski seek hard, 'scientific evidence', of design in nature. Dembski works hard to convince scientists that science needs to include the study of intelligent causes. He wants to be included in the inner circle of science, presumably to avoid the label of non-scientific that has been attached to so-called creation science. I agree with Barbour (2000: 14), who calls it 'scientism' to assume that science is the only reliable source of knowledge.

Both parties agree that the actions of God can be empirically verified. Not only is God needed to explain certain events, the mode of God's action is seen to be direct intervention. Of course, the atheist would deny that God exists in the context of their analysis of such events, but the common point of departure is that if God exists, he/she must be detectable through the methods of science. Dembski talks of 'injections of information' that can be detected in the form of complex specified information (CSI) captured in design. Dembski (1999:104) claims that he is not a deist, but a theist since he wants to assert that God is empirically detectable. His definition of theism is contentious. One can ask: What comes first, the adherence to theism or the empirical evidence? The answer is probably that the world-view — the belief system — comes first. If we believe that God exists and intervenes in the world, then we will find evidence of God's interaction with the world. Similarly, naturalism assumes that nature is self-sufficient and hence will probably not find evidence of God.

Of course, as Dembski (1999:13) acknowledges, his approach leaves him open to the charge of practising bad science and bad theology. As Barbour (2000:14) notes: 'the concept of God is not a hypothesis formulated to explain the relation between particular events in the world in competition with scientific hypotheses'. Furthermore, intelligent design can be seen as a new version of the God-of-the-gaps strategy, in which gaps in our knowledge about how information is produced are taken to be gaps in processes into which God needs to inject information (Barbour 2000:99). Dembski's response is that intelligent design is a research programme at the interface between science and theology (1999:13). The programme does not include research into the nature of God, however, as that is seen to be fixed or received truth, but science must be expanded. Information is used as the key element in this research programme at the interface and, as we have noted, it is a malleable concept with many interpretations that can be used to support one's particular position.

The key issue is that we have a conflict between two belief systems, each of which claims to encompass the whole of reality. Thus we have theism in conflict with a 'metaphysics of materialism' and not in conflict with science (Barbour 2000:14). Barbour (:16) accuses adherents of this conflict model of perpetuating the 'false dilemma of having to choose between science and religion'.

6.2.3 Independence

In the context of biology and the battles caused by creationism in the USA, a popular response has been that there can be no conflict between science and religion, since they are independent, mutually exclusive domains with different methods and functions in human life (Barbour 2000:99). From the scientific side, Stephen Jay Gould is perhaps the most famous exponent of this approach with his principle of non-overlapping *magesteria* (NOMA) (Barbour 2000:99-100). A *magisterium* is a domain of teaching authority. Science covers the empirical realm of fact and theory, while religion covers the question of meaning and moral value (:100). This is perhaps better known as the split between the How vs Why questions. This position dismisses both the deriving of philosophical conclusions from science and the natural theology approach (such as the intelligent design argument of Dembski).

Theologically speaking, independence is favoured by neo-orthodoxy since it holds divine revelation to be pre-eminent and does not want to rely on human reason, thus dismissing natural theology (:100-101). From this perspective, the issue of the origin of biological information would be seen as being part of a general line of thinking that God created the world and that there is a relationship between God and the world, but it would not be seen as providing evidence of any kind (:101). Barbour's critique of neo-orthodoxy is that the emphasis on transcendence leads to a gap between God and nature, and to a neglect of divine immanence and ongoing creation (:101).

Another popular theological approach has been the use of the distinction between primary and secondary causes that was used by Thomas Aquinas (Barbour 2000:101-103). An example of this approach can be seen in the work of William Stoeger, a Jesuit astrophysicist. In the context of an assessment of the biological evidence for teleology, he has maintained a careful distinction between the level of metaphysics and theology versus the level of science (Stoeger 1998:163-190). Scientists do investigations in terms of efficient causes and often ignore final causes, whereas Stoeger would argue on a metaphysical level, and as a Christian, for a primordial initiating cause (:187, 186). In contrast to Gitt, Stoeger argues that we cannot conclude on 'purely scientific and philosophical grounds' that a conscious divine purpose exists (:186). God's intentions are made clear by revelation (:190). God's intentions are not evident in evolutionary history, nor are they contradicted by it (:190). When Stoeger talks of biological information, specifically about the genotype, he uses the concept of a *recipe* rather than that of a *blueprint* (:178). The genome controls processes but does not describe the details of the outcomes. Stoeger would not talk of a primordial blueprint that contained all the necessary information for life, as Gitt would, but of the general course of evolution towards complexity that can be interpreted as inevitable in the universe in which we live (:180). The relationship between the two levels is that the findings of science partially constrain how we understand God's intentions (:190). Complete independence is therefore probably not possible, since all our thinking is coloured by our knowledge of the scientific view of the world.

6.2.4 Dialogue

Dialogue is a very popular approach, which has also been extensively criticised, especially by those who hold the conflict thesis. The attempt is often made to show similarities between presuppositions, methods and concepts (Barbour 2000:23). Emphasis is placed on the fact that the methods of the two fields or domains are comparable, for example that both science and theology use conceptual models and analogies for the unobservable, and that the concepts used may be analogous. Independence, as we have seen, emphasises the differences. It differs from an integration approach in that less emphasis is placed on the fundamental oneness of the challenge that is faced, namely how to make sense of the world, and less emphasis on the common response that is given, namely the fundamental metaphorical nature of our understanding of the world. In addition, a dialogue approach does recognise the significant differences that do exist.

The shared presupposition can be formulated as follows: the world is intelligible, but has to be investigated; the information is there, but has to be decoded. Christians hold that the world is created by God with a rational order, and thus could have been other than it is; information has been embedded, hence the need for and the possibility of decoding, partly through scientific methods.

Let us examine the methods of science and theology. Barbour (2000:25) says that scientific 'theories do not arise from logical analysis of data but from acts of creative imagination in which analogies and models often play a role'. Unobservable entities are imagined on the basis of conceptual models. Scientific data are theory-laden (:25). In terms of the transition from data to information to understanding, the role of metaphors and models is essential. We can and do speak of religious data such as religious experiences, texts and rituals. This data is also 'theory-laden' with conceptual interpretations, and metaphors and models are also used. Although the religious data and religious beliefs cannot be empirically verified and replicated, 'they can be approached with ... the same spirit of inquiry found in science', and the 'scientific criteria of coherence, comprehensiveness and fruitfulness have their parallels in religious thought' (:25).

We have in this dissertation focused mainly on the conceptual parallels between science and theology. God's activity in the world can be thought of as the communication of information (Barbour 2000:27). As we have discussed[110], God's action can be seen as a non-energetic input of information, a selection out of the many possibilities present in chaotic processes that brings about new structures (:167). The divine creating Word also involves the communication of meaning and structure which has to be interpreted in a wider context (:108). A parallel can be drawn with biological information, in which, for example, the meaning of DNA is dependent on almost the whole cell with its various functions (:106).

Barbour (2000:164) discusses a conceptual parallel for a theological understanding of God's relation to nature in which God is seen as 'the designer of a self-organising process'. We have discussed the differences between Dembski and Davies. Design can be viewed as a prepared plan in the mind of God, which is played out by the world and in which chance cannot play a role. However, in the context of self-organising systems, with the general tendency towards greater complexity, both law and chance are part of design. Barbour (:165) talks of a 'revised deism in which God designed the world as a many-levelled creative process of law and chance' and gives Paul Davies as an example of someone adopting this position. This position can lead

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[110] Refer to Subsection 5.6.4: *Active information*.

to a distant and inactive God. Niels Gregersen attributes a more active role to God by proposing that God acts as a *structuring cause*, limiting the range of possibilities within which creatures can act, and not as a *triggering cause* that would unilaterally determine events (:165). This can also be seen as the input of information, in which a bit of information halves the possibilities. Gregersen (1998:360) talks of the *autonomous* processes in evolutionary systems being at the same time *theonomous* processes 'if God is the stimulating power of inspiration who elicits the most fruitful probability spaces in which the creatures try out their pathways, and who also restricts other possibility pathways'. The important point is that Gregersen is willing to part with the traditional omnipotent sovereign God, and, although it may be that the dialogue with science has pushed him in this direction, he does find biblical support for a God of self-limitation. In any case, it demonstrates that one must be willing to shift one's thinking away from traditional paths when participating in the dialogue, which brings us to Integration, the next category.

6.2.5 Integration

Barbour (2000:83) acknowledges that 'there is no sharp line' between the Dialogue and Integration groups of proponents. We do have a 'scale' of increasing integration. As we have discussed in the introduction to this chapter, Barbour (2000:27-28) identifies three distinct versions of Integration, namely natural theology, a theology of nature and a systematic synthesis, with differing degrees of integration.

Natural theology

As an example of natural theology, we have discussed Dembski's work on intelligent design, which shows that the argument for design is alive today. The Anthropic Principle has also been the subject of much debate. Barbour (2000:30) thinks that natural theology has 'great appeal in a world of religious pluralism, since it starts from scientific data on which we might expect agreement despite cultural and religious differences' and it is also appeals on a personal level due to the wonder and awe that the findings of science evoke. In the case of integration rather than conflict, there is one big difference: 'integration-minded' proponents of design do not claim that the argument from design offers conclusive evidence of theism, whereas Dembski claims at least an overwhelming likelihood if not absolutely conclusive evidence. The more modest claim is made that 'belief in a Designer is more plausible than (or at least as plausible as) alternative proposals' (:30). Barbour (:30) acknowledges that the main limitation of this argument is that it can, at best, only lead to a remote deistic God. This is why Dembski (1999:104) asserts that he is not a deist, but a theist since he wants to assert that God is empirically detectable. Natural theology can be combined with theistic beliefs 'based on personal religious experience and a historical tradition' (Barbour 2000:30).

A theology of nature

In contrast to a natural theology, a theology of nature has as its point of departure a religious tradition and not the findings of science (Barbour 2000:31). Scientific findings lead to the reformulation of some of the traditional theological doctrines, especially that of creation and anthropology. This approach tries to harmonise religious beliefs with scientific knowledge and in the process leads to greater adjustments than would be done in the context of a Dialogue type of approach. Consistency of theological doctrines with the broad and well-established results of science is sought and not direct implication or proof. The purpose is not to argue from scientific evidence to God as natural theology does. Our scientific understanding of how nature works has an impact on our thinking regarding the relation between God and nature. In our discussion on Dialogue, we have covered the conceptual parallels based on scientific concepts of God's activity in the world. A theology of nature goes further; an example is the models of God the Creator that have been created as a result of theological reformulation (:59). We have also discussed the close relationship between models and metaphors and analogies in both science and theology. We have noted that a metaphor leads to a rethinking of *all* the concepts involved. In the Bible we encounter many different models of God as Creator: God as a designer imposing order on chaos (Genesis), as a potter forming an object (Jer. 18:6, Isa. 64.8), as an architect laying the foundations of a building (Job 38:4), God as a gardener (Gen. 2:8), God as Spirit active in continuing creation (Ps. 104.30), God creating through the Word (John 1), and God ruling the universe as Lord and King (Barbour 2000:60-61). Some of these models are easier to harmonise with scientific findings than others.

The potter analogy 'assumes the production of a completed, static product' which does not agree well with the scientific understanding of nature as an 'ongoing, dynamic, evolutionary process', while the gardener concept and God as Spirit have greater possibilities (:60-1). The view of God as King has connotations of omnipotence and predestination which clash with evolutionary views of nature. We have mentioned the analogy between the divine Word and the communication of information in the previous section. Polkinghorne and others have proposed a model of God as communicator of information that does not clash with scientific laws. Dippel talked of the 'Divine Informaticus', God as the source of information. The important point is that the purpose is not to use science to prove that God exists, but that science is used as the source of new analogies and metaphors for talking about God (:61).

Barbour (2000:88) sees the various proposals, such as that of Robert Russell[111] that God can act in quantum indeterminacies, as a theology of nature - 'that is, a way in which the God in whom we believe on other grounds might be conceived to act in ways consistent with scientific theories'. We cannot base an argument for God's existence on quantum indeterminacies since we could have argued that the uncertainties are due to human ignorance or that it is purely chance that operates. The purpose of these proposals is to show that the traditional view of divine omnipotence can be sustained without violating the laws of physics (:89). In order to guard against claims that this approach is implicitly reductionist, Russell holds that God acts at the quantum level and also at higher levels as a top-down cause (:87). We have discussed Peacocke and Polkinghorne's formulation of top-down causation under the heading of *active information*[112]. Peacocke holds that God's action is a boundary condition or constraint on the relationships at lower levels and that God's purposes are communicated through the patterns of events in the world (:172). These patterns are what Dembski has called intelligent design and what Gitt has formulated many information laws to try to explain. Peacocke has also used many models of God's relation to the world, such as the whole/part relation with God as the all-encompassing whole, and the mind/body relation, with God as the world's mind

[111] Russell (1998:191-223).

[112] Subsection 5.6.4: *Active information*.

(:115). The mind/body relation has also been used by Clayton, for example to defend top-down causality by referring to the fact that ideas can cause changes in the brain (:173). There has been a progression in the integration of the bottom-up and top-down approaches. Clayton analyses the emergence of higher-level phenomena from physical constituents, building a case for what he calls *emergent monism* (:173). In addition, following Peacocke, he works with the mind/body relation as an analogy for God's relation to the world, defending panentheism, in which the world is in God, but God is more than the world (:173).

Barbour's contention is that classic ideas of omnipotence coupled with simplistic concepts of design lead to the distant God of deism (2000:114). God as the determiner of quantum-level indeterminacies brings God very close, inside reality as it were, but does have a reductionist flavour. Top-down causation guards against reductionism and talks of God's role being at the systems level. Peacocke does start to rethink some key issues such as omnipotence, stressing the self-limitation of God that God suffers with the world (:115). We have referred to the move from classic theism to deism to panentheism. All of these do still seem to have elements of ad hoc accommodation to the findings of science. In order to achieve greater consistency between science and central religious beliefs, some people do take the bold leap of rethinking the whole system of God and creation. We therefore next discuss systematic syntheses.

A systematic synthesis

We have discussed the adjustments and reformulations of traditional doctrines. A more systematic approach is possible in which 'both science and religion can contribute to a coherent world-view elaborated in a comprehensive metaphysics' which provides the 'set of general concepts in terms of which diverse aspects of reality can be interpreted' (Barbour 2000:34). Such an inclusive metaphysics then serves as an area for common reflection by the scientist, theologian and philosopher (:34).

Barbour (2000:34) puts forward process theology 'as a promising candidate for a mediating role today because it was itself formulated under the influence of both scientific and religious ideas'. We have previously discussed the application of process thought by Haught, Van der Lubbe and Laurent [113]. The process view of nature holds (under the influence of quantum physics) that 'processes of change and relationships between events are more fundamental than enduring self-contained objects' and that 'nature is a dynamic web of interconnected events, characterised by novelty as well as order' (:34). The basic constituents of reality are not 'two kinds of enduring substance (mind and matter), or one kind (matter), but *one kind of event with two aspects or two phases*' [author's italics] (:35, 146). Events are 'constituted by their relationships and their contexts in space and time' and can be 'organised in diverse ways, leading to an organisational pluralism of many levels' (:146). The starting point of process philosophy is the human experience as known from within, hence the view that 'all integrated events at any level have an inner reality and an outer reality', which take on' different forms at different levels' (:174, :146). Whitehead attributes subjective experience to diverse systems, it simply has 'progressively attenuated forms' as we move from people to animals, cells and atoms (:146). Unintegrated aggregates such as stones or plants do not have a form of subjective experience. Consciousness appears in 'animals with a central nervous system as a radically new emergent' and involves the 'unification of information from the past and from the body with a new element: the contrast of past and future, the entertainment of possibilities, the comparison of alternatives' (:148). In fact, any unified entity at any level 'contributes something of its own in the way it appropriates its past, relates itself to various possibilities and produces a novel synthesis that is not strictly deducible from the antecedents' (:174-175). This leads to different sorts of causality, all of which are non-coercive. Every new event can be seen as a 'present response (self-cause) to past events (efficient cause) in terms of potentialities grasped (final cause)' (:175).

Process philosophy leads to a different view of all aspects of reality, including conscious beings. It also leads to a different view of God. Whitehead sees God's role as being 'the ordering of potentialities' and God as the *'primordial ground of order* structures the potential forms of relationship before they are actualized'[author's

[113] See Chapter 5, Section 5.3: *Enriching our concept of God*, Subsection 5.2.7: *An example of the use of information-based analogies in theology* and Subsection 5.6.6: *A process perspective* (which deals with God's interaction with the world).

italics] (Barbour 2000:175). God is also the 'ground of novelty, presenting new possibilities along with alternatives which are left open' (:175). God influences the world through the valuation of certain potentialities to which particular creatures can respond, without determining the response (:175). This can be regarded as another way of describing information-flow from God to the world. Van der Lubbe and Laurent (1992:87) talk of God limiting the 'multiplicity of unbounded possibilities'. Haught (2000:73) views God as 'the ultimate source of the novel informational patterns available to evolution'. Every entity is thus the 'joint product of past causes, divine purposes and the entity's own activity (Barbour 2000:175).

Whitehead emphasises that God is also influenced by the world (:175). The central categories of process philosophy (temporality, interaction, mutual relatedness) also apply to God. God is temporal in the sense that the 'divine experience changes in receiving from the world and contributing to it' (:175). Thus we have a two-way information flow between God and the world. God's purposes are eternal but God's knowledge is updated by events. God 'influences the creatures by being part of the data to which they respond' (:175). In addition, 'God is supremely sensitive to the world, supplementing its accomplishments by seeing them in relation to the infinite resources of potential forms and reflecting back to the world a specific and relevant goal' (:175).

Theologians such as Johan Cobb and David Griffin have used process thought to reformulate Christian beliefs (as discussed by Barbour 2000:175). The dipolar character of process-theism is expressed by referring to God as *'creative-responsive'* love. *God as creative* is the 'primordial source of order and novelty, which can be identified with the biblical concept of *logos* as rational principle and divine Word' (:175). *God as responsive* is temporal, as we have discussed above, and is affected by the world. God's relation with people is non-coercive, always depending on the free responses of people, all of whom are equally loved and called by God (:176). Cobb and Griffin see Christ as 'God's supreme act', the incarnation of the *logos*, 'the universal source of order, novelty and creative transformation' (:176).

To Barbour (2000:177), process thought offers distinctive answers to problems in the 'classical monarchical model' of God. Process thought is 'in tune with the evolutionary view of nature as a dynamic process of becoming, always changing and developing, radically temporal in character' (:177). The slow process of evolution is consistent with God's evocative rather than controlling role. All entities are interdependent, and therefore there are no problems with a soul-body dualism. Genuine chance is no longer a threat to God's control as in the monarchical model. We have covered the attack on the role of chance that Dembski has made. Process thought makes indeterminacy one of its basic postulates and affirms both order and chance or openness in nature, since the divine purpose is 'understood to have unchanging goals, but not a detailed eternal plan' (:177). God is viewed as 'the source of novelty and order' and not as the 'transcendent Sovereign of classical Christianity' (:35). Human freedom is embraced, we are seen to be participants in an 'unfinished universe' and omnipotence and predestination are repudiated in favour of a 'God of persuasion' (:178). God is not seen to be powerless, but instead of the power of control, which results in a zero-sum game (I win, you lose), we have the power of empowerment, which results in a positive-sum game for both parties (:179).

Human sin is understood as a 'product of human freedom and insecurity' and suffering is no longer a divine punishment, but the part-and-parcel of struggle present in the evolutionary world which results in greater value (Barbour 2000:178). In any case, God is no longer omnipotent, and we cannot make God responsible for particular forms of evil. Instead, God is with us in our suffering and works to redeem it (:178).

Barbour (2000:179) stresses that interreligious dialogue is encouraged by process theism which is non-exclusive due to the acknowledgement that God's creative process is at work at all points in nature and history. According to Barbour (:179), process thought does allow one to speak of the 'particnlarity of divine initiatives in specific traditions and in the lives and experience of specific persons'. Process thought is not deistic, the idea of God's continuing action in the world is supported, including 'actions under special conditions that reveal God's purposes with exceptional depth and clarity' (:179).

Barbour's conclusion is that process thought offers a framework that encourages dialogue among world religions, as an 'alternative to both the militancy of absolutism and the vagueness of relativism' (:179). He feels that 'we can accept our rootedness in a particular community and yet remain open to the experience of other communities'.

In reaction to this outline of process thought, we may well ask whether the metaphysics has been developed to support a particular viewpoint of how God ought to be, or whether it follows 'naturally' from a systematic development of the implications of the results of science. Some of the criticisms against process theism are also instructive. The question is asked whether the process deity is worthy of worship since he/she/it is not all-powerful (Peterson 1999:400). However, God could choose to be powerless. This critique seems to stem from a Greek conception of God as an all-powerful being. Peterson (:400) also asks: 'If process theists do not conceive of God as personal but rather as a principle, how can they make sense of anything close to theistic worship?'. This critique stems from a religious belief system and a certain conception of what a personal God is. We have discussed how our concepts of life and intelligence may change due to research done on artificial life. It may well be that the concept of person and personal agency undergoes a transformation.

Barbour (2000:37) makes the important point that although a systematic metaphysics can assist in the search for a coherent vision of a theology of nature, 'neither science nor religion should be equated with a metaphysical system' since there is the danger that 'scientific or religious ideas are distorted to fit a preconceived synthesis that claims to encompass all reality'. We need to acknowledge our metaphysical system and its influence on all aspects of our thinking. Our experience is diverse and we distort it if we try to fit it into rigid compartments called religion or science, but also when trying to 'force it into a neat intellectual system' (:37-38). Barbour states (:38) that a 'coherent vision of reality must allow for the distinctiveness of differing types of experience'.

In any case, it is probably a good idea to be sceptical about systems. Since we have been talking about process thought, it is appropriate to add this quote from Alfred North Whitehead's book, *Adventures of Ideas*:

> Systems, scientific and philosophic, come and go. Each method of limited understanding is at length exhausted. In its prime each system is a triumphant success; in its decay it is an obstructive nuisance.
>
> (as quoted in Sowa:2001).

6.2.6 Which typology?

With respect to the question as to which typology of relations between science and religion is preferred, Barbour's answer is that Dialogue and Integration are 'more promising ways to bring scientific and religious insights together than either Conflict or Independence' (Barbour 2000:179). I agree that Dialogue and Integration can lead to greater insights into how little we really understand. We do need to be aware of the complexity of this undertaking at all times and try to understand and respect the depths and subtlety of thinking that exist in both science and religion. Dialogue and Integration would seem to elicit such a careful and respectful approach better than the Conflict approach in which entrenched positions are being defended. Furthermore, the Independence approach may leave unexplored the richness of the interaction between science and religion. The Integration approach does contain the challenge of avoiding the force-fit of scientific and religious ideas into a conceptual system that was created to give voice to one's ideas of how reality should be. In the end, the most important issue may be to retain a sense of wonder, to be humble, and to be self-critical of one's motives and assumptions.

It is now time end this discussion by looking into the future to see what riches might be waiting for us.

7 The role of information in the science and theology dialogue of the future

It is interesting that Claude Shannon, the father of the fundamental theory of information, was 'horrified to find that information theory was becoming - well, popular' and wrote a paper in 1956 entitled: *The bandwagon* in which he declared that information theory was being greatly oversold (Waldrop 2001:71). I agree with this statement. In this dissertation I have tried to distinguish carefully between counting information, meaning information and shaping information. However, as we have discussed,[114] our understanding of how reality is based on information is growing rapidly and it provides us with a cornucopia of ideas and concepts that we can use (with the necessary care) to understand our world better. We cannot ignore the pervasive impact of information concepts on all fields of science and the growth of the 'information-computer' approach[115] to science. It is a reality that we are no longer living in the clock/force era, or the steam engine/energy era, but in the computer/information era. Some would say that we are entering the era in which the world is considered as a universal language and that we live in the semiosphere in which the biosphere is immersed[116].

The importance of information in the science and theology dialogue lies in the rolc that information will continue to play in connecting the complex hierarchy of organisational levels which stretch from the fundamental entities of matter, energy and information to living entities, and ultimately to people in language-using communities. In this hierarchy, there are a few crucial gaps in our understanding and foremost amongst these is the mystery of life's origin. Information plays a central and integrating role here as well. We have established that the ability to perform complex information processing is what distinguishes the living from the non-living. Barbour

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[114] Subsection 5.6.8: *Applying our information-based understanding of reality to the issue of divine action.*

[115] Siegfried (2000:240), see Subsection 5.6.8.5.

[116] The sign-relation network that forms between creatures exchanging signs constitutes an emergent level which is called the semiosphere (Hoffmeyer 1996:58-59). See Section 2.3: *The biological roots of information - from biosphere to semiosphere.*

(2000:167) believes that God's purpose was to create people and not just intelligent information processors, and hence he prefers to draw his analogies for God's communication 'primarily from human life, rather than from genetic codes or computer programs'. I think that we need to be wary of underestimating the reach of the bottom-up approach - concepts are developing that may, in future, bridge the gap between counting information and meaning information. The concept of statistical complexity as a measure of the ability of complex adaptive systems to predict their environment is a promising candidate[117]. I would not want to limit the communication between God and creation.

Apart from the use of information in connecting the hierarchy of organisational levels, we also have the fact that we have grown accustomed to carving up nature into levels, studied by different disciplines, with distinct sets of operational concepts. In our tour through the hierarchy of organisational levels, we focused on the disciplines of physics, biology, sociology, linguistics, etc. Information concepts are used in all these fields and in the interface between them. The bridging of the gap between, say, biology and physics, or science and theology is not easy. We have examined in detail the problems of using in biology the information concepts from physics. A variety of approaches have been developed that try to bridge the gap between hierarchical levels and contexts of enquiry. For example, there are process theology, biosemiotics, research into artificial life, studies of consciousness, and concepts such as top-down causation, emergent properties, supervenience, etc. The variety of approaches will increase and computational approaches will become ever more important to understanding life. The study of artificial life is here to stay and will become increasingly sophisticated as we come to understand better how to simulate the complexities of biological life and as our available computing power increases exponentially.

The fundamental challenge - given our assumption that there is only one reality - is that our various disciplines and approaches are all limited. In order to increase our understanding, we will have to communicate across the artificial boundaries between our disciplines. The science-theology dialogue needs to continue, with increased

[117]Discussed in Subsection 5.6.7.9: *Consciousness, observers and complexity*.

depth, precision and richness. Information will play an important role in integrating and deepening our understanding. Metaphysics and physics, when harmonised, could have a major impact on theology and the science-theology dialogue. We have discussed the idea (which has a long philosophical history[118]) that form or pattern is a metaphysical characteristic of entities. Information is then seen as performing a patterning of the world, creating comprehensive wholes, which should not be dissected by science in a mechanistic way. Physics is moving away from its mechanistic approaches as in the work of John Wheeler and his 'It from bit' concept, which considers all of reality as answers to Yes-No questions and information as the 'stuff' out of which the universe is made.

As we have said before, perhaps in future we will talk of 'information' as the new metaphysics, since 'information' is now coming to the fore as that which is really beyond physics.

The effect of this on the science and theology dialogue will probably be that we will see an increasing number of *Integration*-type approaches, especially systematic syntheses. Process theology, to my mind, has made the most of our information-based understanding of reality. As an example, we have noted the process view of God[119]; God is seen as being the immanent source of the pattern out of which reality flows. God's action is non-interventionist but essential. Especially important is the idea that the relation between God and the world is a dynamic two-way communication. God creates possibilities and imposes a pattern on these possibilities. The possibilities can only be realised through their selection by creation. The cosmos participates in creation and this participation can be seen as a series of Yes-No decisions. This line of thinking is one example of how Wheeler's idea that all things physical have an immaterial, information-theoretical origin enables new integration models of science and theology to emerge. In my opinion, this will be the most important source of new ways of thinking about God, the world and ourselves.

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[118] The history of this idea ranges from Aristotle to Whitehead, as mentioned in Subsection 5.2.6: *An example of the use of information-based analogies in theology.*

[119] See the discussion of John Haught's work in Subsection 5.2.6: *An example of the use of information-based analogies in theology* and the discussion in Subsection 5.6.8.2: *Laws, computation and matter.*

At the same time we need to heed the warning of Barbour (2000:180), who stresses that the diversity of reality cannot be captured by a single model since all models are limited and partial. Certain models may represent certain aspects of reality better than others. Barbour (:180) gives the example of God's relation with people being different from God's relationship with rocks. Therefore we should guard against overdoing the pursuit of coherence or integration, which might neglect the differences between models. We can say that neither science nor religion, nor any system developed by human thought, can capture the richness of reality. Barbour (:180) reminds us that:

> ... the use of diverse models can keep us from the idolatry that occurs when we take any one model of God too literally. Only in worship can we acknowledge the mystery of God and the pretensions of any system of thought claiming to have mapped out God's ways.

Perhaps the *Conflict*-model in the science and theology dialogue is here to stay for some time, with an ensuing variation in the intelligent design arguments. I favour the view that science cannot be used to prove or disprove God's existence. However, the scientific results can be used as a source of new ways of talking metaphorically about God. As a trained scientist, I want to guard against the God-of-the-gaps problem. I think that the intelligent design movement are building their house on sand since irreducible complexity may be better understood in the near future. I agree with Gregersen (2000:29-31) that the role of theology is not to explain the world and that we should be wary of conflating the levels of a natural and a theological explanation. The challenge is how to avoid conflation while engaging in dialogue with science.

The mind/matter dualism question is going to receive more attention. We should also obviate the central control versus local control dichotomy. The study of cellular automata (CA) promises to unravel how local computational intelligence can achieve global co-ordination. This will be the source of new ways of understanding God's creative actions as a property of the cosmos as a whole. The increased understanding of non-local laws will also make our view of the universe more holistic.

We cannot deny the difficulties that lie ahead. Information is a complex concept. The metaphorical use of information is also complex. We need to be aware that the science of information is in its infancy and when we ask whether a particular information-based metaphor rings true with science, we need to be aware of just how speculative information science can be. Care must be taken in using these concepts in the science-theology dialogue so that issues are illuminated rather than obscured.

We need to be aware of the dangers of accepting new scientific myths too easily due to the general awe in which science's methods and results are held. Ultimately, our judgement as to whether a myth is good or bad lies outside science.

References

Adams, D 1979. *The hitch hikers's guide to the galaxy*. London: Pan Books Ltd.

Ayala, F J 1998. The evolution of life: An overview, in Russell, Stoeger, & Ayala 1998:21-57.

Barbour, I 1974. *Myths, models, and paradigms*. New York: Harper & Row.

Barbour, I 2000. *When science meets religion*. New York: Harper San Francisco.

Barrow, J & Tipler, F 1986. *The anthropic cosmological principle*. New York: Oxford University Press.

Bateson, G [1972] 2000. *Steps to an ecology of mind*. Paperback. University of Chicago Edition 2000. Chicago: University of Chicago Press.

Beardslee, W A 1993. s v 'Logos'. *The Oxford companion to the Bible*. New York:Oxford University Press, Inc.

Behe, M J 1998. *Darwin's black box: The biochemical challenge to evolution*. New York: Touchstone, Simon & Schuster.

Behe, M J 1999. God...Sort of. Review of The Fifth Miracle: The search for the origin and meaning of life. *First Things* 94, 42-45.

Brown, J 2000. *Minds, machines and the multiverse: The quest for the quantum*. New York: Simon & Schuster.

Checkland, P 1981. *Systems thinking, systems practice*. Chichester: John Wiley & Sons.

Cilliers, P 1998. *Complexity and postmodernism: Understanding complex systems.* London: Routledge.

Collins Latin Dictionary Plus Grammar 1997.

Crabtree, H 1991. *The Christian life: Traditional metaphors and contemporary theologies.* Fortress: Minneapolis. (Harvard Dissertations in Religion, Number 29).

Danesi, M 1989. The neurological coordinates of metaphor. *Communication and Cognition* 22, 73-86.

Davies, P C W [1999] 2000. *The fifth miracle: The search for the origin and meaning of life.* Paperback. First Touchstone Edition 2000. New York: Simon & Schuster.

Dembski, W A (ed) 1998a. *Mere creation.* Downers Grove, Illinois: InterVarsity Press.

Dembski, W A 1998b. *The design inference: Eliminating chance through small probabilities.* Cambridge: Cambridge University Press.

Dembski, W A 1999. *Intelligent design: The bridge between science and theology.* Downers Grove, Illinois: InterVarsity Press.

Deutsch, D 1998. *The fabric of reality.* London: Penguin Books.

Du Rand, J A 1990. *Johannese perspektiewe, Deel 1, Inleiding tot die Johannese geskrifte.* Halfway House: Orion.

Du Toit, C W (ed) 2000a. *Evolution and creativity: A new dialogue between faith and knowledge.* Pretoria: Research Institute for Theology and Religion, UNISA.

Du Toit, C W 2000b. *Evolutionary biology as a link between religion and knowledge,* in Du Toit (ed) 2000:1-24.

Eldredge, N 2000. *The triumph of evolution: and the failure of creationism*. New York: W H Freeman and Company.

Emmeche, C & Hoffmeyer, J 1991. From language to nature: The semiotic metaphor in biology. *Semiotica* 84, 1-42. (Available from URL: http://www.nbi.dk/~emmeche/cePubl/91a.frolan.html, [Accessed 17 February 2001])

Fauconnier, G [1981] 1987. *Aspects of the theory of communication*, tr by M van Schoor. Paperback. 2nd ed, Pretoria and Cape Town: Academica.

Frieden, B R 1998. *Physics from Fisher information: a unification*. Cambridge: Cambridge University Press.

Gitt, W 1993. *Did God use evolution?* Bielefeld: Christeliche Literatur-Verbreitung e.V.

Gitt, W 1997. *In the beginning was information*. Bielefeld: Christeliche Literatur-Verbreitung e.V.

Godfrey-Smith, P 2000. Information, arbitrariness and selection: Comments on Maynard Smith. *Philosophy of Science* 67, 202-207.

Goode, S 1999. Scientists find evidence of God. *Insight* 19 April.(Available from URL: http://www.arn.org/docs/insight499.htm, [Accessed 26 November 2001])

Goodenough, U 2000. Reflections on scientific and religious metaphor. *Zygon* 35, 233-240.

Gregersen, N H & Van Huyssteen, J W 1998. *Rethinking theology and science: Six models for the current dialogue*. Grand Rapids: William B. Eerdmans Publishing Company.

Gregersen, N H 1998. The idea of creation and the theory of autopoietic processes. *Zygon* 33, 333-367.

Gregersen, N H 2000. God: The creator of creativity. In: Du Toit 2000:25-56.

Harms, W F 1998. The use of information theory in epistemology. *Philosophy of Science* 65, 472-501.

Haught, J F 2000. *God after Darwin: A theology of evolution.* Boulder, Colorado: Westview Press.

Hesse, M 1998. Is science the new religion?, in Fraser 1998:120-135.

Hester, M 1972. *Metaphor and aspect seeing*, in Shibles, 1972, 114.

Hoffmeyer, J 1996. *Signs of meaning in the universe*, tr by B J Haveland. Bloomington & Indianapolis: Indiana University Press.

Hoffmeyer, J 1997. Biosemiotics: Towards a new synthesis on biology. *European Journal for Semiotic Studies* 9, 335-376. (Available from URL: http://www.gypsymoth.ento.vt.edu/~sharov/biosem/hoffmeyr.html, [Accessed 17 February 2001])

Hoffmeyer, J 2001. Personal website. (Available from URL: http://www.molbio.ku.dk/MolBioPages/abk/PersonalPages/Jesper/Hoffmeyer.html, [Accessed 17 February 2001])

Holder, R 2000. Review of *The design inference* by W A Dembski. *Science and Christian Belief* 12, 180-181.

Horgan, J 1999. *The undiscovered mind: How the brain defies explanation.* London: Weidenfeld & Nicholson.

Kauffman, S 1996. *At home in the universe: The search for laws of self-organisation and complexity.* New York and Oxford: Oxford University Press.

Lakoff, G & Johnson, M 1980. *Metaphors we live by.* Chicago: University of Chicago Press.

Lakoff, G & Johnson, M 1999. *Philosophy in the flesh: The embodied mind and its challenge to Western thought.* New York: Basic Books.

Liebenberg, J 2000. Mind and metaphor: Embodiment and the grounding of understanding, in Du Toit (ed) 2000: 276-302.

Lucas, E 2001. Review of intelligent design: The bridge between science and theology of W A Dembski. *Science and Christian Belief* 13, 180-182.

McGrath, A E 1998. *The foundations of dialogue in science and religion.* Oxford: Blackwell Publishers.

Moltmann, J 1995. Reflections on chaos and God's interaction with the world from a Trinitarian perspective, in Russell, Murphy & Peacocke 1995:205-210.

Morris, T V (ed) 1994. *God and the philosophers.* New York: Oxford University Press.

Murphy, N 1997. *Reconciling theology and science: A radical reformation perspective.* Kitchener, Ontario: Pandora Press.

Murray, M J 1994. Seek and you will find, in Morris 1994:61-76.

New Bible Dictionary 1982. Second edition. s v 'Logos'

Peacocke, A R [1990] 1993. *Theology for a scientific age.* Enlarged ed. London: SCM.

Peacocke, A R 1995. A response to Polkinghorne's article "Creatio continua and divine action", *Science and Christian Belief* 7, 109-115.

Peacocke, A R 1996. The incarnation of the informing self-expressing word of God, in Richardson &Wildman 1996:321-339.

Pennock, R [1999] 2000. *Tower of Babel.* First paperback edition. Cambridge: MIT Press.

Peterson, M L 1999. The problem of evil, in Quinn & Taliaferro 1999:393-401.

Polkinghorne, J C 1989. *Science and providence.* London: SPCK.

Polkinghorne, J C 1995. Creatio continua and divine action, *Science and Christian Belief* 7, 101-108.

Polkinghorne, J C 1996. *Scientists as theologians: A comparison of the writings of Ian Barbour, Arthur Peacocke and John Polkinghorne.* London: SPCK.

Puddefoot, J 1992. Information and creation, in Wassermann, Kirby & Rordof 1992:7-25.

Puddefoot, J 1996. Information theory, biology and Christology, in Richardson & Wildman 1996:301-319.

Quinn P L & Taliaferro C (eds) [1997] 1999. *A companion to philosophy of religion.* Paperback. Oxford: Blackwell.

Reader's Digest Great Encyclopaedic Dictionary 1964. s v 'Gauss'.

Richardson, W M & Wildman, W J (eds) 1996. *Religion and science: History, method, dialogue.* New York: Routledge.

Russell, J R, Murphy, N & Peacocke A R (eds) 1995. *Chaos and complexity: Scientific perspectives on divine action.* Vatican City State: Vatican Observatory Publications.

Russell, J R, Stoeger, W J & Ayala FJ (eds) 1998. *Evolutionary and molecular biology: Scientific perspectives on divine action.* Vatican City State: Vatican Observatory Publications.

Russell, J R 1998. Special providence and genetic mutation: A new defence of theistic evolution, in Russell, Stoeger, & Ayala 1998:191-223.

Sarkar, S 2000. Information in genetics and developmental biology: Comments on Maynard Smith. *Philosophy of Science* 67, 208-213.

Schmitz-Moormann K 1992. The evolution of information, in Wassermann, Kirby & Rordof 1992:172-184.

Shannon, C & Weaver, W 1949. *The mathematical theory of communication.* Urbana, Illinois: University of Illinois Press.

Shibles, W (ed) 1972. *Essays on metaphor.* White Water, WI: Language.

Siegfried, T 2000. *The bit and the pendulum: From quantum computing to m theory – The new physics of information.* New York: John Wiley & Sons, Inc.

Smith, J M 2000a. The concept of information in biology. *Philosophy of Science* 67, 177-194.

Smith, J M 2000b. Reply to commentaries. *Philosophy of Science* 67, 214-218.

Soskice, J M 1985. *Metaphor and religious language.* Oxford: Oxford University Press.

Sowa, J F 2001. *Signs, processes and language games: Foundations for ontology.* (Available from URL: http://www.jfsowa.com/pubs/signproc.htm [Accessed 19 October 2001])

Sterelny, K 2000. The "genetic program" program: A commentary on Maynard Smith on information in biology. *Philosophy of Science* 67, 195-201.

Stoeger, W 1998. The immanent directionality of the evolutionary process, and its relationship to teleology, in Russell, Stoeger, & Ayala 1998:163-190.

Tipler, F J 1994. *The physics of immortality: Modern cosmology, God and the resurrection of the dead.* London:Macmillan.

Trigg, R 1998. *Rationality and religion: Does faith need reason?* Oxford: Blackwell Publishers.

Van Besien, F 1989. Metaphors in scientific language. *Communication and Cognition* 22, 5-22.

Van der Lubbe J C A & Laurent J W A 1992. Information as a hinge category between science and theology and its impact on the idea of God, in Wassermann, Kirby & Rordof 1992:83-90.

Van Dijk, P 1992. Revelation and information, in Wassermann, Kirby & Rordof 1992:91-96.

Van Huyssteen, J W 1998. *Duet or duel?: Theology and science in a postmodern world.* Harrisburg: Trinity Press International.

Van Huyssteen, J W 1999. *The shaping of rationality: Towards interdisciplinarity in theology and science.* Grand Rapids, Michigan: Eerdmans.

Van Noppen, J P 1992. Interpretation fallacies in theographic communication, in Wassermann, Kirby & Rordof 1992:142-148.

Waldrop, M M 2001. Claude Shannon: Reluctant father of the digital age. *Technology Review* 104 (6), 64-71.

Wassermann, C, Kirby, R & Rordof, B (eds) 1992. *The Science and theology of information*. Publications de la Faculte de Theologie de l'Universite de Geneve No. 16. Geneva: Labor et Fides.

Wassermann, C 1992. Theological remarks on Carl Friedrich von Wiezsacker's concept of an "Information Stream" as an interpretation of quantum reality, in Wassermann, Kirby & Rordof 1992:97-102.

Wildman, W J 1996. The quest for harmony: An interpretation of contemporary theology and science, in Richardson & Wildman 1996:41-60.

Woudstra, E 1989. Analogies in non-specialist journals. *Communication and Cognition* 22, 47-60.

Yob, I M 1992. Religious metaphor and scientific model: Grounds for comparison. *Religious Studies* 28, 475-485.

Appendix A - Gitt's 30 information theorems

From Gitt's book, *In the Beginning was Information* (Gitt:1997). The relevant page numbers are listed with each theorem.

Theorem 1: The fundamental quantity information is a non-material (mental) entity. It is not a property of matter, so that purely material processes are fundamentally precluded as sources of information (:47).

Theorem 2: Information only arises through an intentional, volitional act (:48).

Theorem 3: Information comprises the non-material foundation for all technological systems and for all works of art (:49).

Theorem 4: A message which has been subject to interference or 'noise', in general comprises more information than an error-free message, according to Shannon's theory (:55).

Theorem 5: Shannon's definition of information exclusively concerns the statistical properties of sequences of symbols; meaning is completely ignored (:57).

Theorem 6: A code is an essential requirement for establishing information(:64).

Theorem 7: The allocation of meanings to the set of available symbols is a mental process depending on convention (:65).

Theorem 8: If a code has been defined by a deliberate convention, it must be strictly adhered to afterwards (:65).

Theorem 9: If the information is to be understood, the particular code must be known to both the sender and the recipient (:65).

Theorem 10: According the Theorem 6 only structures which are based on a code can represent information. This is a necessary but not sufficient condition for the establishment of information (:65).

Theorem 11: A code system is always the result of a mental process (it requires an intelligent origin or inventor) (:67).

Theorem 12: Any given piece of information can be represented by any selected code (page no?).

Theorem 13: Any piece of information has been transmitted by somebody and is meant for somebody. A sender and a recipient are always involved whenever and wherever information is concerned (:70).

Theorem 14: Any entity, to be accepted as information, must entail semantics; it must be meaningful (:70).

Theorem 15: When its progress along the chain of transmission events is traced backwards, every piece of information leads to a mental source, the mind of the sender (:70).

Theorem 16: If a chain of symbols comprises only a **statistical sequence** of characters, it does not represent information (:71).

Theorem 17: Information always entails a pragmatic aspect (:74).

Theorem 18: Information is able to cause the recipient to take some action (stimulate, initialise, or implement). This reactive functioning of information is valid for both inanimate systems (e.g. computers, and an automatic car wash) as well as living organisms (e.g. activities in cells, actions of animals, and activities of human beings) (:75).

Theorem 20: The teleological aspect of information is the most important level, since it comprises the intentions of the sender. The sum total of the four lower levels is that they are only a means for attaining the purpose (apobetics) (:78).

Theorem 21: The five aspects of information (statistics, syntax, semantics, pragmatics, and apobetics) are valid for both the sender and the recipient. The five levels are involved in a continuous interplay between the two (:78).

Theorem 22: The separate aspects of information are inter-linked in such a way that every lower level is a necessary requisite for the realisation of the next one above it (:78).

Theorem 23: There is no known natural law through which matter can give rise to information, neither is any physical process or material phenomenon known that can do this (:79).

Theorem 24: Information requires a material medium for storage (:85).

Theorem 25: Biological information is not an exceptional kind of information, but it differs from other systems in that it has a very high storage density and that it obviously employs extremely ingenious concepts (:97).

Theorem 26: The information present in living beings must have had a mental source (:98).

Theorem 27: Any model for the origin of life (and of information) based solely on physical anchor chemical processes is inherently false (:99).

Theorem 28: There is no known law of nature, no known process and no known sequence of events which can cause information to originate by itself in matter (:107).

Theorem 29: Every piece of creative information represents some mental effort and can be traced to a personal idea-giver who exercised his own free will, and who is endowed with an intelligent mind (:113).

Theorem 30: New information can only originate in a creative thought process (:113).

Appendix B - Gitt's properties, forms and kinds of information

From Gitt's book, *In the Beginning was Information* (Gitt:1997). The relevant page numbers are listed below.

Two fundamental properties of information (84):

- **Property 1**: Information is not the thing itself, neither is it a condition, but it is an abstract representation of material realities or conceptual relationships, like problem formulations, ideas, programs, or algorithms. The representation is in a suitable coding system and the realities could be objects, or physical, chemical or biological conditions. The reality being represented is usually not present at the time and place of the transfer of information, neither can it be observed or measured at that moment.

- **Property 2**: Information always plays a substitutionary role. The encoding of reality is a mental process.

There are three forms of information (:108-110):

- Constructional/Creative information (:108)
- Operational information (:109)
- Communication information (:110).

There are three kinds of transmitted information (:112-113):

- Copied information
- Reproduced information
- Creative information (relevant theorems are 29 and 30).