Introduction

The mathematical relationship between information and entropy described in the preceding chapters requires further paradigm shifts in at least four areas:

1. The relationship defined by equations (3.10) and (3.11) flies in the face of the relationship as traditionally defined by the communications engineers.

2. The equations imply that entropy may have a negative value, as indicated in fig. 3.2.

3. The exponential growth of the curve in the upper left quadrant of the graph (fig. 3.2) indicates that the values for information $I$ grow extremely large for very small negative changes in entropy. Furthermore, there is no theoretical upper limit for information.

4. Although entropy may be increasing throughout the universe, so is information. The universe, rather than ending up as a uniform soup of particles with very low energies – the entropic death – may instead, end up in a state in which all matter and energy have been converted into pure information.

Let us examine these implications more closely.
Information and Entropy as Viewed by the Communications Engineers

The idea that information and entropy are somehow related has been around for some time. Leo Szilard in a paper in 1929 embarked on an exploration of Maxwell's demon which could sort out the "swifter molecules" from the slower ones in a chamber of gas. Szilard considered that the demon possessed information about the molecules of gas and was converting information into a form of negative entropy.*

It was the communications engineering field which first saw the utility of applying the idea of entropy to the transmission of information. Claude Shannon (1948), in his classic treatise "A mathematical theory of communication" related information to entropy. However, the concepts elucidated by Shannon and co-workers differ markedly from those discussed in the present exploration. Shannon never claimed to have developed a theory of information. As indicated in the title of his original work, he was interested in developing a mathematical theory of communication. However, Shannon did treat the "information" being communicated as an abstract, quantifiable entity. It is not unnatural therefore, that since the information being transmitted could be handled mathematically, the impression grew that Shannon had devised a theory of information. This was unfortunate.

Colin Cherry (1978, pp. 43-44) has reviewed the earlier (1928) work of R.V.L. Hartley, who defined information as the successive selection of signs or words from a given list. Hartley, concerned with the transmission of information, rejected all subjective factors such as meaning, since his interest lay in the transmission of signs or physical signals. As such, he could show that a message of N signs chosen from an alphabet of S signs,

* In the real world, biological systems utilising membranes are filled with such demons at work: For example, the green alga Valonia consists of a hollow sphere with liquid inside. This liquid is known to contain concentrations of potassium a thousand-fold greater than the surrounding sea water. Similarly the human kidney is continuously sorting out molecules from the blood, excreting the potentially harmful ones (including excess water). A kidney requires energy in order to perform its work. As such, it is one of many examples of biological machines which convert energy into information. That is, biological demons perform the work of Maxwell's demons - sorting molecules and decreasing entropy - but do so only as a result of an input of energy.