Dr Andy Hammond. andy.hammond@lineone.net October 2011. *I should stress from the outset that I am not trying to give an accurate account of how Prigogine sees equilibrium, nor how accurately Weaver's description of Prigogine's views is in the quote below, nor how these views fit in to current scientific thinking (either mainstream or fringe). My intention here is to simply look at the ideas through dialectical eyes. So here goes...*

"Ilya Prigogine has demonstrated that when an "open system," one which exchanges matter and/or energy with its environment, has reached a state of maximum entropy, its molecules are in a state of equilibrium. Spontaneously, small fluctuations can increase in amplitude, bringing the system into a "far-from-equilibrium" state. Perhaps it is the instability of subatomic "particles" (events) on the microscopic level that causes fluctuations on the so-called macroscopic level of molecules. At any rate, strongly fluctuating molecules in a far-from-equilibrium state are highly unstable. Responding to internal and/or external influences, they may either degenerate into chaos or reorganize at a higher level of complexity. An example would be the molecules in a homogeneous state reorganizing themselves into crystals. Prigogine and Stengers (1984) summarize: "We now know that far from equilibrium, new types of structures may originate spontaneously. In far-from-equilibrium conditions we may have transformation from disorder, from thermal chaos [entropy] into order" (p. 12). From this transformation may originate "New dynamic states of matter" reflecting the transaction of a given system with its surroundings."

(This description is from Weaver, Constance, 1985. "Parallels Between New Paradigms in Science and in Reading and Literary Theories: An Essay Review," *Research in the Teaching of English*, page 303. She quotes from Prigogine, I. and Stengers I, 1984. *Order out of chaos: Man's new dialogue with nature.* New York: Bantam.)

Before I begin I will outline the salient features from the above quote. Imagine an open system where the molecules are in a state of dynamic equilibrium. This means that there will be exchanges of matter and/or energy with the 'external' environment. It is found that small fluctuations in the system can, at times, result in a shift from equilibrium to a far-from-equilibrium state. Such a shift can lead to a reorganisation at a higher level of complexity or a transformation into a "new dynamic state of matter."

In part the significance of this description/discovery lies in understanding the obsession the Victorians had with entropy and the 'cold death of the universe.' This obsession had its philosophical foundation in mechanical materialism, a philosophy that insisted everything in the world could be explained through mechanical principles – the world and everything in it is a machine. If a steam engine was run as a closed system then it would stop moving as differences in temperature levelled out. The engine would become cold and stop. According to this view any closed system would inevitably slide downwards into entropy, a state from which there was no return because there would be no heat energy (strictly speaking, differences in energy between molecules) to ‘drive’ the system. If the universe was a closed system then it would become colder and colder until nothing could move... the cold death. (There were alternative materialist positions to this. Engels poured scorn on the cold death/entropy ‘problem’ from the viewpoint of dialectical materialism.) The arrival of Einstein’s theory of relativity and quantum physics forced through a more complicated and subtle picture of the world. We now know that systems do not inevitably move to a cold death but can become rearranged and remain dynamic. This is the world of the quote above.

The cold death scenario relied heavily on how a closed system was defined. This was contested even at the time of its popularity. Important lessons can be learnt from looking at the arguments for and against it but for my purposes here I will simply note that the universe is no longer considered to be a closed system. Maybe I’ll get round to it at a later date.

On closed systems, Prigogina’s work can be used to illustrate the point that ultimately there is no such thing as a closed system. In the long run all systems are open. By definition, any system that can remain closed indefinitely must be isolated (completely cut off) from the rest of the universe so that there are no interactions with other energy or matter to disturb it. *But this would mean it is no longer part of the universe*... so all systems are open. Consequently all systems are vulnerable to an interchange of matter and/or energy with their ‘external’ environment.

Systems can only be ‘closed’ for a certain period of time (dependent on the nature of the system). At some point they will interact with the ‘external’ environment or will be disturbed by other levels of organisation within the system (and these other levels may not have been ‘closed’ anyway, they may have been interacting with the external environment whilst one level of the system appears ‘closed’.)

From this it follows that any equilibrium can only be an equilibrium at one level of organisation. Those levels above and below it can impact on it. In the quote on Prigogine’s work reference is made to the possible role of subatomic particles (a lower level) impacting on the molecular level (and consequently disturbing the molecular equilibrium under consideration). Although there is an equilibrium state at the molecular level, at the subatomic level there is a state of flux and this non-equilibrium state can disturb the molecular equilibrium state. This notion of *any* equilibrium only being temporary was missing from the picture of the mechanical materialists, in part due to no understanding of levels of organisation.

The view of equilibrium I have espoused here has consequences for determinacy (i.e. cause and effect). At various times in the twentieth century, with the discovery of peculiar properties in quantum physics, some scientists and philosophers denied the existence of determinacy. But the problem was not with determinacy as such. The problem was with the conception as inherited from mechanical materialism (which is still commonly, and mistakenly, held today). In this version of determinacy there is a single cause for a particular phenomenon/event and a single effect. Cause and effect are lined in a linear manner: cause – effect – cause – effect, etc.

Yet even when these objections were initially raised around the turn of the twentieth century there was an alternative materialism (dialectical) with a determinacy much more in keeping with the new discoveries in physics. In this materialism any phenomenon is due to multiple causes and effects. Take one example, what causes tuberculosis? Several answers are possible, including... the bacterium invading the lungs, poverty, problems with hygiene, the airborne transmission of the disease, etc. Here we see multiple causes for the disease at more than one level of organisation. Similarly, in my interpretation of equilibrium states, cause and effect can be seen to be simultaneously present at various levels of organisation and also present in the *interactions* between the levels at the same time.

Two final points. Firstly, it can be seen that the cold death scenario was in part the product of a particular philosophical outlook, i.e. mechanical materialism (there were other factors, such as the socio-political that have been more than adequately covered by other writers). Secondly, where is the dialectical materialism in my interpretation? In particular:

everything is in a state of flux --- even equilibrium is not a static state but must be interpreted in dynamic terms;

levels of organisation are qualitatively different from each other, having properties unique to each level, but they also interact with each other --- so they are both separate and yet not separate;

material entities exist but to understand them it is necessary to consider them in 'real time', i.e. as they interact, nothing can be understood without reference to process.