Chapter 9
Discussion
Open Ended

Introduction

The rumor is that John Von Neumann told Shannon to start using the word *Entropy* as no one knew what it meant and could thus win any battle. The actual definition of the word was first used in Thermodynamics where entropy meant the content of transformation. Clerk Maxwell however thought that entropy should mean the opposite "The part which *can* be converted into mechanical work," ~page 252. This new meaning however where entropy is the unavailability of energy worked neatly with the two laws of thermodynamics,

1. The energy of the universe is constant/You can't win
2. The entropy of the universe always increases/You can't break even

Then immediately Maxwell turned around and decided to follow Clausius' definition of the word entropy.

These laws could also be expressed in a much more serious cosmic tone where it stated that the universe itself is running down, it is a degenerative one-way street. William Thomson, otherwise known as Lord Kelvin, expressed the second law in an incredibly bleak way
"Although mechanical energy is indestructible," he declared in 1862, "there is a universal tendency to its dissipation, which produces gradual augmentation and diffusion of heat, cessation of motion, and exhaustion of potential energy through the material universe. The result of this would be a state of universal rest and death," page~253
What are other ways we see these two laws?

Energy Entropy(The pun was so close yet so far away)

Entropy now dictated the fate of the universe in H.G. Well's novel, *The Time Machine*, where Freud used the word entropy because it "opposes the undoing of what has already occurred," page ~253. Thomson though preferred dissipation for this definition and Maxwell decided to focus on the confusion of entropy, that confusion is the focal point of entropy. The counter to the dissipated, useless energy was the available, useful energy. Dissipated energy was immaterial, strangely unphysical, forcing the idea that dissipation depends on knowledge, which we will touch on later.
If disorder is entropy, what is order?

Pioneers of physics envisioned a box perfectly split in half, filled with atoms, one half was fast and warm atoms, the other was full of cold and slow atoms. This process could be calculated mathematically but given the scale, probability had to be introduced in the picture. After the box mixed, people found the hotter atoms would cool down when combined with the cooler atoms.

"Why can the process not be reversed? In Newton's equations of motion, time can have a plus sign or a minus sign; the mathematics works either way. In the real world past and future cannot be interchanged so easily," page ~254.

Maxwell gives a reason, stating that if we zoom in, we can see that the behavior of individual molecules is the same backwards and forwards, a loop. Pan out, the box of gas remains constant and unchanging.

"The 2nd law of Thermodynamics has the same degree of truth as the statement that if you throw a tumblerful of water into the sea, you cannot get the same tumblerful of water out again," page ~255 . Now the second law of thermodynamics is merely probabilistic. You could look for that tumblerful of water, but it would be extremely rare for you get the **exact** tumblerful of water you first introduced.

Physicists now entered the conversation, talking about; macrostates: where all gases are at the top of the box, and microstates: all possible arrangement of all particles, all positions and all velocities. Now the 2nd law indicates that the universe will flow from less likely (order) to more likely(chaotic)

Could the idea of the molecules constantly looping be said for us as well, the whole idea of history repeating itself? If so, what do we see when we zoom out and look at our timeline as a whole?

Entropy and its Demons

Maxwell then thought about what if the box could be divided back into hot and cold, slow and fast, what if the box could be put back into its original state?

"and yet no work has been done, only the intelligence of a very observant and neat-fingered being has been employed." The being defies ordinary probabilities," page ~256.

"He differs from real living animals only [only!] in extreme smallness and agility," page~257

"All nature is supposed to be filled with infinite swarms of absurd little, microscopic imps," he sniffed. "When men like Maxwell, of Cambridge, and Thomson, of Glasgow, lend their sanction to such a crude hypothetical fancy as that of little devils knocking and kicking the atoms this way and that …, we may well ask, What next?" He missed the point. Maxwell had not meant his demon to exist, except as a teaching device," page ~257.

Now the 2nd law had been changed again, now being all statistics where the demon change's chance with purpose, using information to reduce entropy. Peeking though we can see this happening as even on the level of molecules, we can see the second law being broken all the time here and there by pure chance, or by a little demon? Is this demon not just meant for separating atoms? Could this demon be applied to the other sciences in situations where there is no seen reason?

Entropy in Physics

The demon is the gateway for transitioning physics to information, making the scientists very envious of this little demons' abilities. With even more advanced technology, scientists noticed that some cells would act as pumps filters, and factories giving the next question, who or what was controlling the living cells? Who do you think controlled these living cells? Does anyone/anything control these cells?

James Johnstone wanted to more ignore the demon of Maxwell as physics only wanted to consider the mean velocities and as such the phenomena of physics became irreversible. Finding how the organism can control the uncontrollable though was essential.

"Is it not strange that while we see that most of our human effort is that of directing natural agencies and energies into paths which they would not otherwise take, we should yet have failed to think of primitive organisms, or even of the tissue elements in the bodies of the higher organisms, as possessing also the power of directing physio-chemical processes?" page ~260

This idea to harness the power of the demon gave birth to the perpetual motion machine which could be seen in the nervous system as "The very existence of a nervous system," he noted, "is dependent on continual dissipation of energy," page ~261. Unfortunately, Szilárd showed that his perpetual motion machine would have to fail as the catch is that information is not free. For when the Demon converted info and energy, Szilárd computed this conversion and found that each unit of information brings a corresponding increase in entropy, specifically by k*log(2) units. The payback comes at the end when clearing memory, this property was the only way to eliminate the paradox, to bring the universe in harmony, "to restore concordance with the Second law," page ~262

Physicist entropy=uncertainty about physical state $S=-\Sigma*p_i*\log(p_i)$
Information theorist entropy=measure of uncertainty of a message $H=-\Sigma*p_i*\log(p_i)$
H is the number of average yes or no questions needed to guess the unknown message

"Nature providing similar answers to similar problems. It is all one problem," page ~262. Shannon identified information with entropy, Wiener said it was negative entropy. Wiener was saying that information meant order, but an orderly thing does not necessarily embody much information.
If Nature provides similar answers to similar questions, what answers has nature given us to what questions?

Schrodinger's Entropy

Organisms will always organize, for example we sort mail, solve jigsaw puzzles, etc. The demon may be described as superintelligent but compared to a real organism it is an idiot savant We are not too different from the demon itself in a way. Making the next question: Is our purpose to curb entropy, to cause order and prevent disorder?

Living creatures are not in entropy, as Schrodinger said, all living things are living because they are doing something, feeding on negative entropy. Claims and statements like these made Schrödinger revolutionary for biologists and a signal for the next problem for physicists. Organisms suck the order out of everything, herbivores and carnivores themselves dine on order.

Schrödinger also saw that biologists had started learning about the hidden patterns of an organism. From sperm cells, egg cells, and chromosomes which all held details of their own given organism. Brillouin would look into crystals to find some clues about the molecular structure of a gene, but the crystals themselves are too orderly and have capacity for self-repair. If the crystals self-regeneration is a reason to it being too orderly, what of an animal with regeneration like lizards, axolotls, etc.? Are they orderly like crystals? Non-orderly like living beings? Somewhere in between?
"The earth is not a closed system, and life feeds upon energy and negative entropy leaking into the earth system.... The cycle reads: first, creation of unstable equilibriums (fuels, food, waterfalls, etc.); then use of these reserves by all living creatures," ~page 266 Brillouin
"Take an issue of The New York Times, the book on cybernetics, and an equal weight of scrap paper," suggested Brillouin. "Do they have the same entropy?" If you are feeding the furnace, yes. But not if you are a reader. There is entropy in the arrangement of the ink spots," ~page 267

Leo Szilard killed the demon at age 62, but continues to haunt the castles of physics as a restless and lovable poltergeist
Schrodinger stated that all living things do not live in entropy, but can we continue to change and curb the path to entropy even after we bite the bucket?