A Final Overview of Atomic and Sub-Atomic Physics

We will now very briefly review the development of ideas in this subject. Certainly this is not the only way of inter-connecting the ideas, but we do feel that it is a useful and rewarding outlook.

We began in essay #1 with a justification of our belief in atoms. Various observations of matter and agreements with thermodynamic theory were seen to lead us to the kinetic particle theory of matter.

Essays #2 and #3 provided us with experimental data from chemical reactions, which made possible the deduction of the relative masses of atoms, discussed in essay #4.

Meanwhile, electrical theory showed the existence of a smallest unit of charge, possessed by a sub-atomic particle - the electron (essay #5). Knowledge of this unit of charge enabled detailed electrical studies which precisely measured the masses of atoms (essay #6). When this was done, it was found that atomic mass occured in whole number multiples of a basic unit, and it was also seen that atoms of the same element could differ in mass by a few of these units. Such differently massive atoms were called isotopes.

In essay #7 we began to probe the atomic interior in the hopes of finding underlying structure. Experiments with alpha particle scattering lead Ernest Rutherford to show that atoms contain a small positively charged nucleus which possesses most of the mass of the atom. Furthermore, the charge on this nucleus is always an integral positive multiple of the electron charge. A little thought suggested that the nucleus consists of two types of particles - the proton, of unit positive charge and mass, and the

neutron, of unit mass but electrically neutral.

In essay #8 we discussed the means by which these particles were observed, and in essay #9 we wrapped up all of our ideas in a basic summary of the atom. This picture had a tiny nucleus of protons and neutrons, surrounded by a vast space filled with electrons which somehow orbited the nucleus. However, there were two serious difficulties with this method. There was no good explanation for the fact that the electrons do not fall into the nucleus, and that the nucleus does not fly apart!

Temporarily placing these problems to one side, we moved on to consider the nature of radiation. In essay #10 we discussed the fact that electromagnetic radiation can be shown to consist of particles, known as photons. In essay #11 we explored a fascinating fact - in addition to wave-like radiation consisting of particles, the particles of matter can be shown to have wave-like characteristics!

The precise meaning and implications of this wave-particle duality were discussed in essay #12, and a useful restatement, known as the Heisenburg uncertainty principle, was mentioned in essay #13.

The knowledge of the wave-particle duality enabled us to re-think our picture of the atom. It would appear that the electrons in the atom must be regarded as standing waves existing in stable arrays around the nucleus. These notions were discussed in essay #15, quantum mechanics. The term quantum mechanics comes from the fact that certain characteristics of the electron pattern can exist only in multiples of a specific amount (known as quanta). This idea was first considered to explain the radiation observations of essay #14 in terms of electron energy changes.

ATOMIC & SUB-ATOMIC PHYSICS

The quantum mechanics description of atomic electron arrangement was put to use in essay #16. This essay explained the repetitive nature of the chemical properties of the elements, as shown in the periodic table of the elements. This was one of our first practical applications of exotic theory.

We then turned our concern to the nucleus of the atom. Essay #17 we discussed the experimental techniques which are employed in the study of the unimaginably small sub-atomic particles. In essay #18 we discussed the various particles which such techniques have found. At this point, we were in a position to consider the nature of the nucleus.

Essay #19 discusses the nature of the nucleus which sub-atomic particle interactions have suggested. We see the nucleus to be about 10^{-14} meters in radius, and incredibly massive. Yet in some respects, this object behaves as though it were almost empty - an observation which lends even more support to the wave-like model of the particles.

Essay #20 concerns itself with the force which holds the nucleus together. We saw that this force appears to be related to certain sub-atomic particles, which theory predicted and experiments observed. In addition, we studied the discrete values of energy which the nucleus may possess - a phenomenon analogous to the behavior of electrons in the atom.

In essay #21 we used our knowledge of the nucleus to describe the cause of natural radiation, and to explain the nature and usefulness of atomic energy. Finally, essay #22 described the theory of forces which nuclear study has suggested. We mentioned that we are now on a scientific frontier - we seek to explain the nature of the fundamental wave-particles, and the forces between them.

CHEMISTRY and BIOLOGY

A Final Overview of Chemistry and Biology

Our universe operates within certain physical laws; and most of the material in our universe is composed of atoms, with electrons whose behavior is explained by quantum mechanics. The interaction of such atoms amongst themselves, within these physical laws, yields the multiplicity of chemical reactions and life processes we continually observe. The quantum properties of atoms determine the way atoms will bond together. The way they bond, and the considerations of Thermodynamics, determine the outcome of any chemical reaction. The properties of water and its solutions, and the properties of carbon compounds give us the basis upon which Life is built.

All life forms have several essential functions in common. We saw how cells are organized to carry out these functions, and how certain cells can differentiate into a complex of variously specialized cells coordinated, as a whole, to carry out these same essential functions. These "multicellular organisms" produce more of these certain cells by sexual reproduction, so as to propogate their species. Over sufficient periods of time the genetic material involved can be altered to produce a variation in this multicellular orgainization, which may be a favourable adaption. This is the basis of Evolution. The same species may adapt differently in different environments, giving us <u>divergent</u> evolution, which, over the past three-billion or so years has left us with a diverse and magnificent assortment of creatures.

Life processes work and develop in a hierarchical manner, as do all complex systems in our Universe.