

DENTAL DISEASE
ITS CHEMICAL CAUSATION AND CURE

DENTAL DISEASE

PREFACE

"If our problem consists in the exact analysis of the means employed by nature to obtain a certain result, the chances are that our rough methods will fail, until the far-off day when some kind of electronic chemistry will be perfected. . . ."—LE COMTE DU NOUY (1936)

AFTER completing the last chapter of this book I chanced to read the above extract, As I had been at work for some time on a system of " electrionic " chemistry which could be applied to dental medicine, it seems possible that the day is not so " far off " which will see the perfection of the system outlined in the following pages.

There is one point, however. that ought to be mentioned by way of explanation. The word " electrionic," which is nearly synonymous with the word " electronic," has been used almost exclusively in this book. The former, indicating a more gradual change and one which is not quite so definitely corpuscular in meaning. seems the more suitable used in the sense intended herein. The changes in the blood would appear to be partly of :in electrical character and partly of discrete electrons in varying orbits; therefore the use of the broader term seems more natural than the narrower, which may, at the same time, be more literally correct in certain respects.

In a preface such as this it appears to be customary to make excuses, for inflicting the author's work. on his readers. My excuse, if one be required, is that, having been interested in Broderick's work in many years and McDonagh's more recently, there seemed much therein that, was difficult for the general practitioner to follow . Bearing in mind that the intelligence and knowledge of these two men was of a very high order, the problem presented was to acquire the fundamental facts upon which their theories were founded. This difficulty was solved by my friend R. H. Nixon, who is

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an analytical chemist. He indicated my path through the intricacies of chemistry; and following this path with a prejudiced but none the less curious mind, the evolution of the following pages was a natural result.

Like " All Gaul " of our schooldays, this thesis is divided into three parts. But it is hoped that that is the only similarity. The first part supplies the basic ideas of modern atomic structure in so far as they form a foundation for the application of colloidal chemistry in its electrionic nature to the constitution of the blood plasma; and, as such, electrionic activity then becomes the basic force of biochemistry.

The second part deals, with the application of the principles enumerated to diagnosis, sufficient details are given to enable the necessary tests to be applied in practice.

The third part shows how to apply those principles, to treatment and offers a new conception of drugs and their effects which, if perhaps revolutionary, is none the less rational.

One main consideration has been foremost, and that was, an intention to keep the story as simple as could be, without being inadequate. Consequently some of the more recent atomic theories have not been included at length. but no doubt with further thought and research these will in turn help to throw more light on the subject of electrionic medicine.

Although written primarily on a dental basis, there should be much to interest the doctor and scientist in the thoughts expressed herein. It is not hoped that the reader will agree with every idea expressed, but at least if he is sufficiently interested to think or argue about the story at all I may consider that the labours of writing this book have not been in vain.

R. G. TORRENS

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My father. J. M. Torrens, who corrected the final manuscript.

And all those others whose works mentioned and unmentioned have contributed to the development of the story of Electronic Medicine.

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DENTAL DISEASE

PART I

**THE CHEMICAL FOUNDATION UPON
WHICH LIFE IS BUILT**

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CHAPTER I

OUTLINE OF APPROACH

Mankind has from time immemorial tended to pursue its route in life by following already established custom, a fact which is well illustrated symbolically in the opening shots of Charlie Chaplin's film *Modern Times*. The first shot shows a flock of sheep running pell-mell along a road. The next shows a flock of men scurrying to work. The connection is surprisingly comic; but nevertheless it has a deep symbolical lesson for us all.

Habit and convention combine to make a force too strong for the average professional man to ignore; he follows his occupation somewhat blindly; an occupation often chosen not by his considered decision, but by his parents or circumstance. Fortunately, for the flock in general, occasionally there has been an individual who stands aside from the tide of daily routine, and asks himself the simple question - WHY? From these few research workers who were not content just to be led along orthodox lines has sprung the world's knowledge; so progress has been rendered possible and inevitable.

Retracing our steps through scientific history for over two thousand years, about 350 B.C. we meet Aristotle, one of the first great thinkers who stood aside; on his expressed ideas was formed the early nucleus upon which the structure of modern science crystallised. He was not content to accept the dictates of custom and to apply established principles to his daily life and action; he reasoned WHY? The outline of his deduction is as follows: Let us analyse the soul of man and find out, the function for which he was intended. Basically man has two subdivisions of function, which are (1) animal and (2) mental. In these he differed from beasts in that he was guided, or could be guided, in his actions by Reason. Hence his eudæmonia, or summum bonum, or "greatest good" lay in the exercise of his

vital faculties in accordance with Virtue. This path lies in activity or well-being. It was not:

(1) Pleasure, but was accompanied by it.

(2) Wealth. although one must have enough to exercise the faculties. (The life of a great scientist, which Aristotle regarded as the highest form of life. did not require very much wealth in those days.)

(3) Honour alone, but was accompanied by it.

(4) Virtue, but was in accordance with it.

The happiness of a really happy man is stable thing, and he will not be upset by little troubles or worries. It takes a very big disturbance to affect him, because his happiness, is internal. But as negatives are never a very satisfactory reply, he then asked "What is Virtue?" Man has a capacity for Virtue, but it is not naturally in him, it is developed and brought out by teaching. He becomes virtuous by doing virtuous things, A child who writes grammatically does so either because he has been dictated to or because he has been taught so to do. But Virtue is not strictly Virtue, until the person acts by reason of the virtue still in him. What then is Virtue? Virtue is praised and Vice is blamed. Men are not praised or blamed for their passions unless in excess; i.e. men are good or bad on account of the Virtues and Vices they possess, and are not judged on account of their passions unless in excess. We are moved by passions and disposed according to our Virtues. Hence the two are separate. Likewise the capacity for passions is not a virtue. Therefore Virtue is a Habit.

This was obviously only part of the answer, as it gave, no indication as to how to cultivate the best Habit. So he then formulated the Doctrine of the Mean: *Virtue is a relative mean between two extreme, between an excess on the one hand, and a deficiency on the other.* It is relative because it is different for each individual and cannot be calculated definitely like an arithmetical mean. Take for example the two extremes,

Cowardice and Rashness _ respectively a defect and an excess - neither could be held as Virtue; but the mean, or a reasonable combination between the two, is obviously the best path, or Virtue (fig. 1).

A few other examples to make the idea quite clear: Temperance is the Virtue between Asceticism and Drunkenness. Meanness on the one hand and extravagance on the other indicate the mean, Generosity.

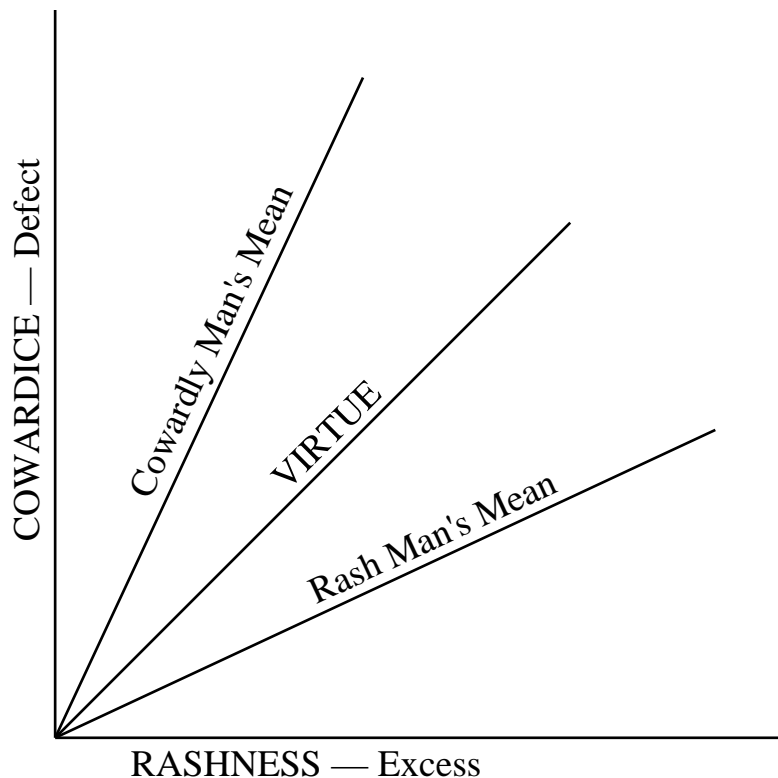


Fig. 1 Doctrine of the Mean (Aristotle)

His rule, for conduct can now be summed up as follows :

- (1) Keep away from the extreme more opposed to the mean.
- (2) Keep away from the extreme to which we are most inclined.
- (3) Give frivolous pleasure a wide berth.

In other words, a rash man should tend to be cowardly with a care not to overdo it. and a cowardly man should tend to be rash. Only by a tendency in the opposite direction to one's inclinations can one's life be modelled in the perfect path of Virtue.

Now this preamble may seem out of place in a tome of purely scientific interest, but it will be seen as we progress that this Doctrine of the Mean has its application to modern medical science. For, by considering the two extremes of dental disease, Caries and Pyorrhœa, we can strike our Mean of Perfect Health.

To-day as we look about a room full of people gathered at any meeting - yes, even medical or dental conferences - how many faces appear to radiate health? By far the greater proportion of people to-day neither look nor feel healthy. Although many of them cannot definitely be diagnosed as ill, they nevertheless cannot be said to be in the best of health. Run-down, off-colour, neurotic, bilious, and similar terms are words of common usage in our everyday life - terms which in a great many instances are applied to men and women who are "organically sound" and might even be classed as A1 for an insurance examination by their medical adviser.

"Organically sound" apparently, with the probable exception of their dental organs. Their teeth may have been filled, or some of them extracted. possibly they wear a plate : if their teeth are perfect their gums are not quite normal- there may be a slight trace of tartar on the subgingival margins of the gums, a slight discolouration of the gingival edge itself with some rolling or inflammation; possibly there may even be well-marked signs of gingivitis. These little points are usually taken to be of only purely dental interest and of little importance. Conditions such as colds, pimples, catarrh. and other slight deviations from good health are frequently regarded as so unimportant as to need no medical attention-a bottle of tonic from the chemist seems all that is necessary to the lay mind.

With regard to this intermediate stage between disease and good health, one might think from the Doctrine of the Mean that this was the proper state as indeed it seems to be by common usage. But as we progress in our search for the laws of Health, we shall see that Health is the mean between two extremes -Caries on the one hand and Pyorrhœa on the other, Acidosis and Alkalosis, Sympathetic Dominant and Parasympathetic Dominant, as described by Broderick (1936). A very delicately balanced position, where the functions of the body and mind work at their maximum efficiency, should be maintained.

How then can these basic facts, these laws, be found ? As we look about the world of science to-day and yesterday, we see chaos, and conflicting opinions usually put forth by specialists, who in their own branch of research have discovered something which they shout from the housetops. Ideas often completely wrong in themselves have contained the germ of truth and have acted as signposts to greater discoveries later. Unfortunately these ideas, accepted for a time, have often left behind misconceptions and faulty nomenclature. For example, the word "atom," which for many years was assumed to refer to the ultimate limits of chemical structure, was named from the Greek words meaning indivisible. Recently the atom has been shown to consist of separate parts, which under certain conditions may be separated. The word "oxygen" came from the Greek, meaning acid producer, because Lavoisier thought that it was necessary in the formation of every acid. Years later it was discovered that hydrogen had this character. The expressions "positive and negative charges " applied to electricity and electrons really mean the reverse — an atom carrying a positive charge means that it requires, or will attempt to gain an electron or a negative charge. Likewise an electric current is a flow of negative particles or electrons. These few examples, together with the enormous divergence of opinion in practically all branches of science to-day, make it extremely difficult to discover the truth.

St Paul wrote "Prove (or try) all things and hold fast that which is good" (1 Thess. v. 21). Let us, therefore investigate all branches of science which seem to have some bearing on life and see if we cannot find the common denominator -- the basis of life, what it is and how it works. Let us reduce life, if we can, to a science.

Now let us ask, What is a science? The answer comes back clear: science is systematised knowledge, an investigation and discovery of laws, a search for principles and causes. in brief -- basic fact. Can medicine to-day be called a science consistent with the suggestion of the foregoing definition? It cannot, because although treatment is improving for many conditions, a number of diseases are still incurable and often the doctor is helpless to do more than alleviate the discomfort temporarily. The common cold, neurotic conditions, cancer, tuberculosis, and a host of other conditions, together with the sale of patent medicines, nostrums, and cure-alls, provide damning evidence that medicine, although greatly advanced, is not yet a science in the true sense of the word; and although it alleviates discomfort, it cannot always prevent disease, in many cases, it cannot even cure.

Let us digress and see how laws in science are ascertained, what they are and how derived. First we start with a working Hypothesis, which is a state of affairs purely imaginary which has been suggested to explain and correlate certain known happenings. As knowledge progresses, and new facts are found to support the Hypothesis, this then becomes Theory which is a reasonable expressed idea to help the growth of knowledge. In other words, Theory is Hypothesis established but not fully proven. It only becomes a law when finally developed and when repeated experiments fail to show other than the one result

The much-discussed but rarely, if ever, formulated "Laws of Nature" are mirages in our lives. Nobody can tell what they are

or how they work. One man's meat is another's poison is an age-old saying, but who can tell us why? How is it that in any large group of tubercular patients, some respond readily to treatment but others become steadily worse? Why is it that hay fever and asthma are such stubborn complaints, in spite of all protein reaction tests? Catarrh of various mucous membranes becomes chronic, pyorrhœa is regarded as almost incurable. In spite of years of research no real answer has been found to the question: Why do teeth decay? Why? and why? and why? There are many "whys" in medicine and dentistry today.

The practitioner, either medical or dental, having treated his patient for some complaint or other with some degree of success, dismisses him as cured; but if he thinks at all he knows full well that in a short time that same patient will be back on his doorstep, or perhaps some other adviser's doorstep, with the same or another complaint. Yet this is the state which frequently is regarded and spoken of as a cure.

Why is it then that medicine has not been able to ascertain the basic facts common to all disease? Wherein does the cause of ill-health lie? What is the fundamental origin of life; what is its structure and its function?

To answer these questions, the author requests the reader to follow as he conducts him through the intricate windings of this mortal life. To explore the field of science and see if it can assist by telling how fearfully and wonderfully we are made. Let us first trace the conception of matter from the earliest time, leaving out those complicated mathematical calculations whereby they were derived, leaving out those details of laborious proof which we may well take as established. Let us study the intrinsic points having a bearing on our subject and try to correlate them with life, to find a basis for Health, and a Positive cure instead of a palliative remedy for Disease.

The conception of matter has developed from the pre-atomic theories to the idea of an electron probably revolving or oscillating around its nucleus or proton. This, electron has, or is a negative charge of electricity, or it may be a wave of energy. Be that as it may, it behaves in a definite manner. As far as we are concerned an electron is potential energy, or conversely energy may even be electrons. Matter and energy are but different forms of the same thing. What that thing is does not affect issue, although further researches may bring more light to bear on the problem and help further at a later date.

All atoms of the elements are built up of varying proportions of these electrons and protons, with increasing complexity as we ascend the periodic system. At the top of this system the radio-active elements are constantly liberating measurable energy and apparently changing their forms into lower elements in so doing. It has been suggested that if the periodic system were written in the form of of an Archimidean spiral, like the shell of a snail, which began at infinity in the centre and ended at infinity on the outside, the elements could be arranged from hydrogen within to uranium on the outside. Then outside again in order of atomic weights (or numbers) could be arranged compounds of the elements, at first simple and then complex. At one section the system would have somewhat radio-active characteristics of an easily controlled character. These compounds could absorb energy from radiation and under suitable environment give out this absorbed energy. We shall see in some measure how this comes about as the electron moves the position of its orbit, or exchanges positions in a chemical equation. Still farther out on the scale would be built up various types of living creatures as enormously complex molecules, and right out at the circumference would be the earth, moon, and stars, and so ad infinitum.

This may seem like a flight of fantasy, but think for a moment how the laws of electro-magnetic waves came into

being and then were amplified. First there was a consciousness of light and colour, then a white beam of sunlight was split up into its component parts. Eventually light rays were proved to consist of waves. At a later date other waves were found -- ultra-violet, α -rays, β - and χ -rays, and cosmic rays of very short length; then on the other side. infra-red, heat, and very large waves of wireless; all these rays or waves forming a complete scale in size from something infinitely small to infinitely large.

Since matter is potential energy, and energy is synonymous with the atom, the possibility of completing a scale of building-up, or aggregation, of atomic particles should not be very difficult to visualise. First the atom was found -- soon it may be expected that science will correlate various forms of matter as it has already done with forms of wave motion or energy.

Finally in our search for knowledge we will attempt to define the two extremes of "unhealth." We find that disease is really a deficiency of electrionic energy in the system on the one hand and an excess of electrionic energy on the other. Having shown the two extremes we can apply Aristotle's Doctrine of the Mean to acquire and maintain good health,

In short, a deficiency of electrons is on the same side, of the fence as an acidosis, sympathetic dominant, increased basal metabolism, dehydration, increased calcium-potassium ratio; whereas an excess is the opposite picture — alkalosis, parasympathetic dominant, decreased basal metabolism, increased potassium-calcium ratio. The mean is, therefore, a happy and harmonious balance between all these and many other factors. In my opinion it is along these lines alone that true diagnosis and correct approach is possible in the treatment of any disease. Our lives are very delicately balanced machines, and it is only by accurate understanding of the factors underlying these points that health will become universal instead of being a comparative rarity as it is to-day.

In concluding this introduction I cannot hold out that there has been discovered a simple cure-all or a simple remedy for all disease. We can, however, take hypotheses and theories and point a way to the laws. A few men working along these rational lines are insufficient to give you laws; but we can explain the theory and say this works in cases we have tried. Therefore take it yourself, and try it. If it works in your case, too, and I have no reason to doubt its success, it will in time become a law.

This thesis is written with the idea of carrying a step further the theories and researches of two great men of this decade, Broderick and McDonagh. Their work has wrought a modern miracle in many cases. Like other original thinkers they are not always credited, but instead often condemned. Because they know so much they are difficult to comprehend. An attempt is made herein to express their ideas in a more simple form. To fully understand their works an extensive specialised knowledge is needed. That knowledge has been simplified and condensed in the following pages, but it has been by no means exhausted. Conclusions have been taken in outline. Should any reader wish for proofs of the scientific statements made he will find ample in the list of recommended books at the end of this work.

As the reader follows through the maze of scientific facts and deductions he cannot fail to be amazed at and interested in the orderliness to be found in life. As the very atom is picked to pieces for our information, and as the wondrous beauty of the world is built up of tiny particles or quanta of energy, I cannot but feel that in investigating these matters we are getting down to the bedrock of life, and here also we are closely in touch with the infinite.

The fundamental conception of the subject is that life is dependent on the conversion of matter into energy, and the living animal obtains this energy from previous conversion of

energy into matter by the plant. It is intended therefore in the subsequent chapters to trace the development of this idea through physical chemistry to biology and kindred sciences to medicine and dentistry. By arranging the facts of life and health in an orderly fashion it may be hoped to ascertain the Laws of Life, so that we may utilise the atomic matter of our bodies, and those of our patients, for the production and maintenance of radiant health, which alone brings that happiness money cannot buy.

CHAPTER II

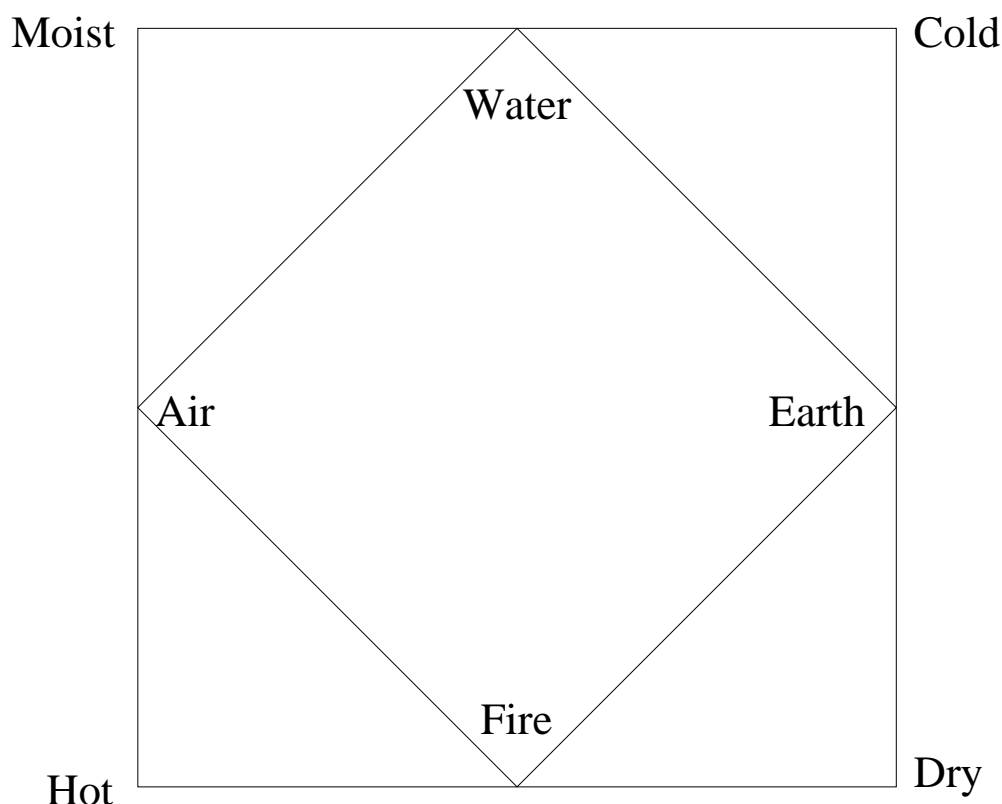
THE STRUCTURE OF MATTER

Looking back into the early history of chemistry we find that the earliest conceptions of the elements were formulated by the ancient Greeks. Thales, about 600 B.C., taught that water was the beginning of all things, Anaximenes suggested air, Herakleitos thought fire was the original substance. About 450 B.C. Empedocles combined these ideas with one of his own, and said that earth, air, fire, and water were the elemental substances, and these were either united or separated by two forces -- attraction and repulsion. At this point it is interesting, to note that the nucleus, of the modern electronic theory of matter is based on the idea of two electro-magnetic forces acting in opposite directions, or positive and negative electrical charges. Here, too, we see evidence of the doctrine of the mean. Either force is potential change or instability, whereas a balanced combination of the two tends towards stability or virtue.

Some time later Aristotle expanded the ideas of previous thinkers, and propounded the idea that primary matter could take on different forms, much in the same way that different fishes might develop from eggs which appeared identical to a visual examination. His elements were really basic properties of matter. Nevertheless, he thought that by a combination of these fundamentals the four elements would be produced. For instance, water was both moist and cold, earth was cold and dry. A glance at fig. 2 will show diagrammatically his conception of this theory. Here, again, it is of interest to compare the latest ideas of atomic construction, which postulate four primary types of matter -- electron, positron, proton, and neutron. Is it not strange that it should take over two thousand years to develop

this theme and prove these points were basically correct?

It was not till a little over a hundred years ago that definite and concrete information began to form out of chaos. For centuries men had been hunting for the Philosopher's Stone, the Universal Solvent, and the Elixir of Life. This quest for an "end-point" delayed progress: and in fact it will be seen later that the "end-point" of disease is being studied to-day in medicine while



the science itself, the basic facts, and fundamental causes are too often neglected. Men sought riches and fame instead of truth, not realising that the only way to obtain a lot out of life is by putting a lot into it. The chaos of chemistry in the early Christian centuries is aptly described by Robert Boyle in his *Sceptical Chemist*, published in 1661, in which he accused learned men of writing "darkly not because they think their notions too precious to be explained, but because they fear that if they were explained men would discern that they are far from precious".

Boyle was probably the first man in comparatively recent years who really studied chemistry for itself and without an ulterior motive. All about him were men who talked loud and

long to cover their undoubted ignorance. Seemingly a parallel could be drawn between ancient and modern: human nature does not seem to change with the passing of the centuries.

It was not until very early in the nineteenth century that the present atomic theory began to form out of the void. In the year 1804 a Manchester schoolmaster, John Dalton, developed the "**Law of Multiple Proportions.**" Briefly this states that substances combine in fixed quantities with simple multiples connecting their relative (or atomic) weights. From this naturally developed the system of arranging and grouping of elements in accordance with their atomic weights, which is the ratio of the weight or mass of any atom compared with that of an atom of hydrogen. Later, more substances were investigated and a nomenclature was developed. The manner in which compounds are named is important, as this usually indicates their composition. The more electro-positive are taken first and the name of the second radicle is adapted with a suffix indicating its relationship. This order of elements is briefly as follows:--

Metals.

Carbon.

Hydrogen.

Nitrogen, Phosphorus, Arsenic.

Sulphur, Selenium, Tellurium.

Halogens.

Oxygen.

The word "electro-positive" must not be confused with the words positive and negative, which are defined later in their relationship to the electron. This point illustrates one of the great difficulties of modern chemistry, i.e. nomenclature not always meaning what it appears to suggest.

When various compounds combine certain phenomena are noticed. Oxygen often forms salts of metals, which have a soapy feel when combined with water, e.g.:



All hydroxide bases have an OH or hydroxyl group in their molecules.

Oxygen forms salts of non-metals which give acid solutions, e.g.:



This difference of behaviour of oxides was used as one means of classification of metals and non-metals. Some compounds appear neutral but absorb acids or alkalis, and in this manner may give an indication of the type of oxide; for example, copper oxide is insoluble in distilled water, but dissolves in acid solution, and is unaffected by alkaline ones; it is therefore classified as a metal.

The manner in which solids are formed from evaporating solution has always been a subject for wonder. Why should certain compounds always form out of solution with a constant shape? Why should alum always crystallise like a cube with its corners chipped off? Students of Crystallography had studied why these sometimes complicated figures of solid geometry should always be uniform for certain substances. The answer was not clear until Lane in Zurich; as recently as 1912, applied the X-ray to the study of atomic structure. Diffraction gratings of known size had previously been used for the determination of wave-length. So Lane photographed X-ray beams, using crystals of various substances as diffraction gratings. The results showed that the small atoms were arranged in a very definite manner, and since matter is largely composed of space the positioning of the tiny- components could be calculated.

The arrangement of sodium and chlorine atoms in common salt is illustrated diagrammatically in fig. 3. It will be seen that there are really no molecules of NaCl but a definite grouping of atoms held together by forces of cohesion, the positive charges

of combined Na holding in place the Cl by virtue of the negative charge of the latter. The centre Na is not really combined but is held in place by the attractive forces around it. i.e. six ions of Cl bearing a negative charge.

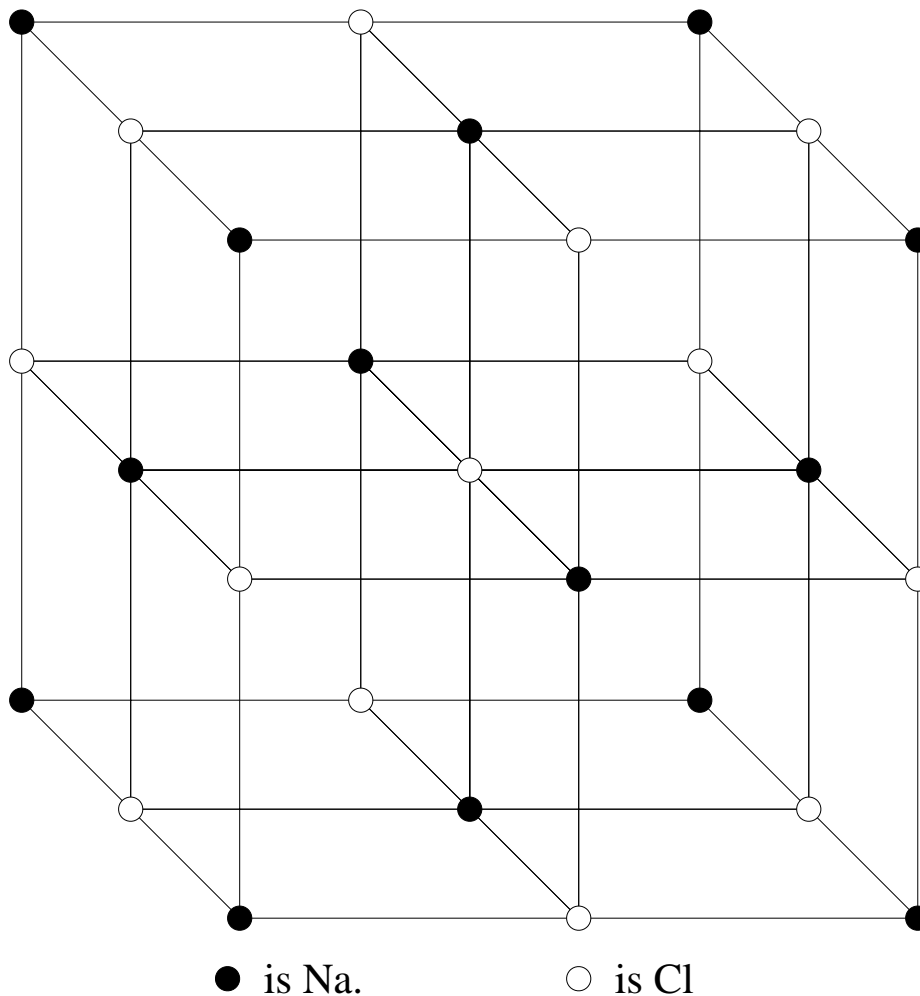


Fig 3. Arrangement of Atoms in Sodium Chloride.

It is almost as difficult to imagine the relative size of the universe as it is, to visualise the size of the atoms and the enormous number of these which go into the building up of our lives and the everyday, objects about us. For example, copper has 85,000,000,000,000,000,000,000 atoms in each cubic centimetre, which incidentally weigh less than 9 grammes. Then, again, there are 50,000,000,000, atoms of gold in each teaspoon of sea-water, This does not, however, really mean very much as it represents approximately 0.0005 gramme per ton. A realisation of this approach to infinity will be necessary later, but meanwhile to continue the story.

For many years the number of known elements had been growing and some method of classifying them was necessary. The first attempt was subdivision into metals and non-metals, then Dohereiner's Triads in 1829. Next, came Cannizzaro, who about 1850 drew attention to Avogadro's hypothesis, and the elements were sorted according to atomic weights. Newlands was the first of the moderns to put forward any really useful suggestions. In a paper to the Chemical Society of London about 1863 he suggested his Law of Octaves. If the elements are arranged in order of atomic weight each eighth element is a kind of repetition of the first, like octaves in a musical scale. This relationship, which was based on the atomic weights, was not quite satisfactory, and was in consequence not too warmly received. Newlands had the germ of all important chemical idea, but unfortunately he was not fully able to correlate it to all known facts.

A short while afterward (1869) the great Russian chemist, Dmitry Ivanovitch Mendeléeff, worked on the idea that the properties of the elements are in periodic dependence on their atomic weight. He arranged the elements according to their main characteristics, and did not hesitate to move an element one or two places till it fitted into his scheme.

His law contains eight paragraphs:--

1. The elements arranged according to atomic weights show periodic properties.
2. Chemically similar elements have atomic weights off nearly the same value (platinum, iridium, osmium) or they increase regularly (potassium, rubidium, caesium).
3. This arrangement indicates the valencies of the elements.
4. Elements most widely distributed in nature have small weights and sharply defined properties.
5. The magnitude of its atomic weight determines the characteristics of the element.

6. Certain unknown elements may yet be discovered whose properties can be foretold by their position in the table.

7. Atomic weight may sometimes be corrected by knowing the details of adjacent elements.

8. Certain properties can be foretold from their atomic weights.

His table was called the Periodic System and is shown in modern form in fig. 4. It will be seen that this consists of nine vertical columns, the last of which is headed O and contains the inert gases. The Roman figures at the head of the groups are all indication of valency. Each of these columns is subdivided into two sections, (a) and (b). A full description of this table can be obtained in any modern text-book on chemistry, but there are several points about the arrangement and properties which will be revealed later in the description of the elements and their properties. It must be pointed out that this table is often given in a slightly different form --- the position of Group O being moved slightly. The arrangement is purely arbitrary and has little if any effect on the periodicity principles which form the basis of the tabulation.

In considering some of the more recent theories of the composition of matter it will be well for the reader to constantly refer to the periodic table (fig. 4) in order to note how the behaviour of various elements depends on their position in the periodic system.

The octet theory of Newlands was open to many objections, so it was developed by G.N.Lewis, who suggested that, omitting hydrogen and helium, we have two periods of eight elements each. i.e. lithium to neon and then sodium to argon. Now since each atom is electrically neutral, it follows that the number of free protons is equal to the number of exterior electrons, which in turn is equal to the atomic number (see chapter V). Hydrogen has one electron which can easily be lost or another gained to

Valency		1	2	3	4 or -4	5 or -3	6 or -2	7 or -1	Max 8	0	
Period	Series	Group									
		I a b	II a b	III a b	IV a b	V a b	VI a ^a b	VII a b	VIII a	0 b	
1	1	H 1								He 2	
2	2	Li 3	Be 4	B 5	C 6	N 7	O 8	F 9		Ne 10	
3	3	Na 11	Mg 12	Al 13	Si 14	P 15	S 16	Cl 17		Ar 18	
4	4	K 19	Ca 20	Sc 21	Ti 22	V 23	Cr 24	Mn 25	Fe 26	Co 27	Ni 28
	5	Cu 29	Zn 30	Ga 31	Ge 32	As 33	Se 34	Br 35			Kr 36
5	6	Rb 37	Sr 38	Y 39	Zr 40	Nb 41	Mo 42	Ma 43	Ru 44	Rh 45	Pd 46
	7	Ag 47	Cd 48	In 49	Sn 50	Sb 51	Te *127.4 52	I *126.9 53			Xe 54
6	8	Cs 55	Ba 56	15 rare earths 57-71	Hf 72	Ta 73	W 74	Re 75	Os 76	Ir 77	Pt 78
	9	Au 79	Hg 80	Tl 81	Pb 82	Bi 83	Po 84	•• 85			Rn 86
7	10	•• 87	Ra 88	Ac 89	Th *231.99 90	Pa *231 91	U 92				

FIG 4. - Periodic table after Mendeléeff (modernised).

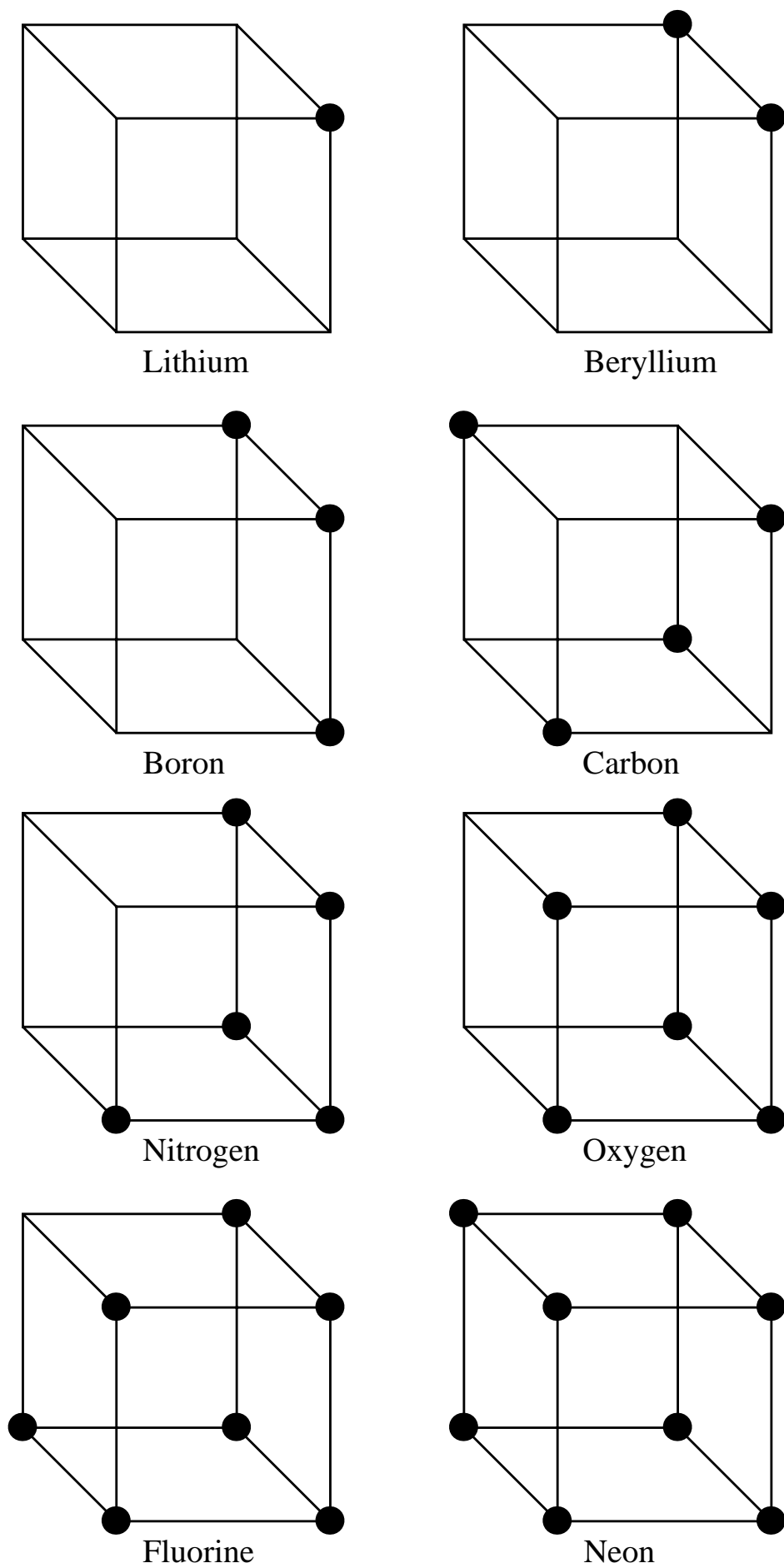


Fig. 5 — Octet theory — Second Period.

simulate the helium structure, which has two electrons in its outer shell.

Succeeding atoms are built up by additional electrons in concentric layers or shells, with the electrons diagrammatically represented at the corners of a cube (fig. 5). In chemical reaction it is only the outer shell which changes, and this, has a tendency to lose all or to gain some to complete the eight. The valency represents the number of electrons which can be -gained or lost by the outer shell, e.g. fluorine can lose seven or gain one, which means it has a valency of 7 or -1 , the positive valency denoting the ability to lose. When elements are combined these electrons are temporarily "loaned" or "borrowed." In the next period, i.e. from sodium to argon, a second layer or shell is built up around the inner completed ring of neon. In the long series the formation is less obvious, the reason for which will be seen later.

The atom is never assumed to have more than eight electrons in its outer layer or shell. Its maximum valency, therefore, is either positive or negative eight. The maximum positive valency is utilised when the outer shell is stripped; the maximum negative valency is used when the outer shell is completed. Inert gases already have complete outer shells of eight and therefore are of little if any use in ordinary chemical reactions.

Hydrogen deviates from the rule of eight as it can react by losing its electron and becoming $+H$. or react as negative element by gaining another electron and taking the helium formation. For example, in lithium hydride the hydrogen is negative, and the lithium after combination has a positive charge; having lost one electron, it takes the helium formation with an extra charge on the nucleus. Hydrogen has acquired another electron and is also in helium configuration, but with an extra negative charge. In lithium fluoride the charges contributed to the change are positive and negative respectively. This is an example of a polar or ionised compound (see Fig. 6 for diagram of changes).

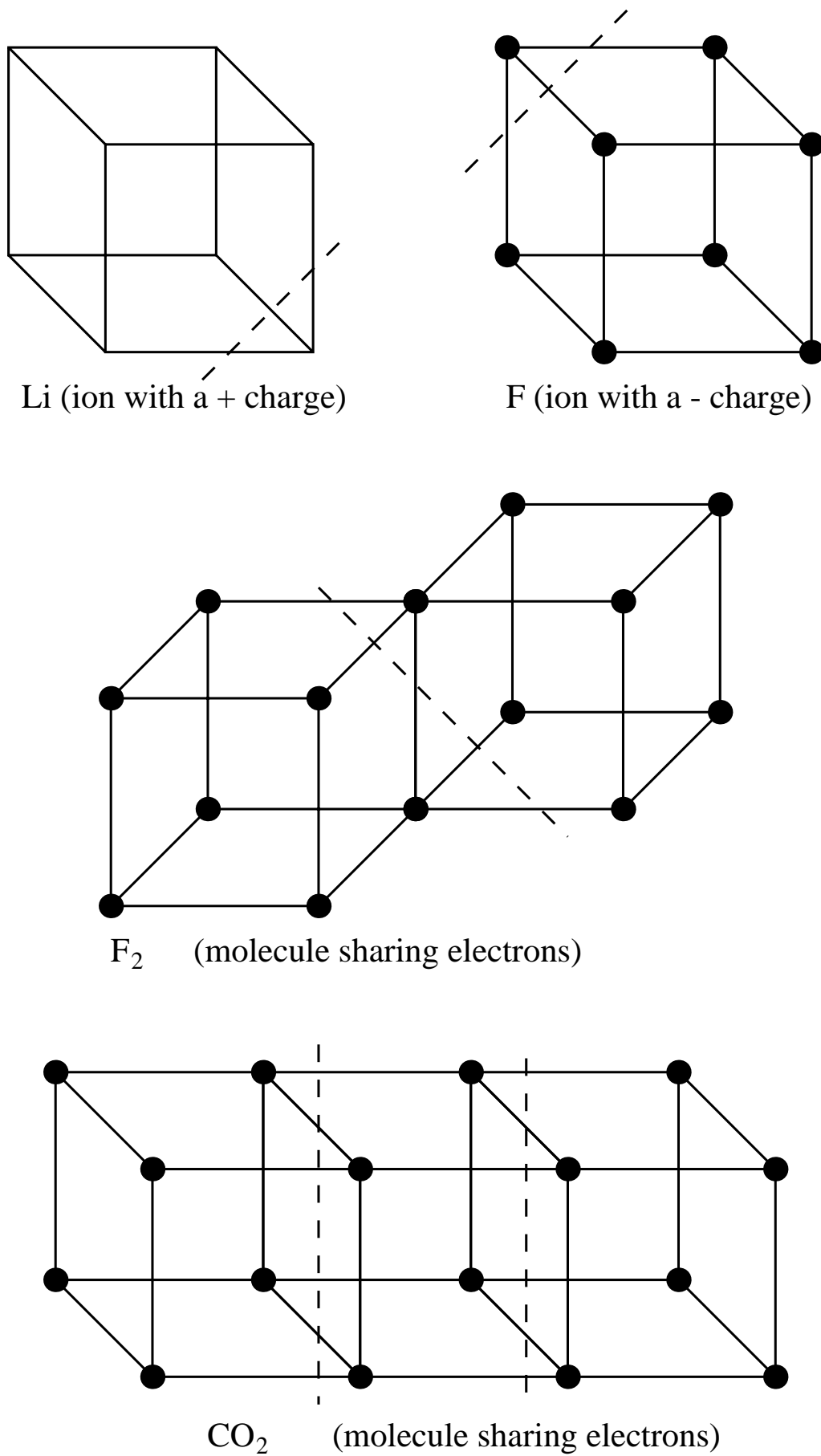


Fig.6. — Polar and Non-polar Compounds (the dotted line marks the division of atoms before combination).

Atoms also may share two electrons with one another as in gases such as fluorine ($F + F = F_2$). In this case two are shared; this constitutes the ordinary chemical bond. A similar happening takes place in water where the oxygen with six outer electrons shares two electrons of hydrogen (two atoms). Therefore these compounds share two pairs of electrons so as to complete the octet round the oxygen.

Carbon dioxide shares in a double manner the central carbon atom, sharing two electrons from each atom of oxygen. In carbon disulphide the carbon atom also holds two electrons in common with each sulphur atom.

We now have two distinct types of formation -- (a) when the atom cubes are fitted edge to edge sharing two electrons, or (b) when face to face where the atoms share four. In the former case we have a single chemical bond and an easily dissociated or ionised molecule or polar compound capable of carrying electric current when in solution. In the other case we have a different type of formation which gives a double bond, a not easily ionised molecule, which is non-polar and incapable of carrying electrical charges when in solution. The former is more stable chemically, as double bonds are easily disturbed in chemical reaction, but they are not so easily disturbed by electrical changes. This fact is of great importance in the treatment of disease by complex organic compounds.

Atoms like those of sodium chloride, which are polar, in which one electron passes from one atom to the other, are potentially ionised and only require the mutual attraction to be diminished to free the ion. This happens when they are dissolved in water. Non-polar compounds which share electrons in common do not ionise in water. Chemical activity or affinity is therefore based on atomic structure -- elements are stable if the outer shell is complete and unstable if electrons are readily gained or lost.

CHAPTER III

ELECTRIONIC ACTIVITY

Having discovered that matter is to a large extent composed of varying arrangements of electrons, it is now necessary to consider how these electrons behave in relationship to various chemical reactions. In these reactions it is advisable to bear in mind the precise relativity of the interchange. Nomenclature is somewhat difficult and may lead to incorrect deductions unless the actual detail of interchange is visualised clearly.

Oxidation and Reduction are particularly to be noted, as they are comparatively frequent happenings in body tissues in health and disease. They are somewhat similar in effect to electrolysis and ionisation, which will be dealt with in due course. It depends on the movement or exchange of electrons. Oxidation can be defined as an increase of relative weight of that part of the molecule carrying negative charge. Oxidation therefore leads to an increase, and reduction on the other hand to a decrease of positive valency. Oxidation is consequently equivalent to radiation or giving of electrons, and reduction to an attraction or acceptance of same. In other words, if an electron of an atom is removed this is synonymous with oxidation, and if one is added that is reduction. To all intents and purposes this is similar to the phenomenon which occurs in ionisation (see fig. 7 and explanation). The chlorine in solution, therefore ionised, under the influence of electrical pressure, gives off its electron and is therefore oxidised.

The removal of a positive charge is equivalent to the addition of a negative charge and also is oxidation, e.g
chlorides of iron —

Ferrous	Fe	Cl ₂	Cl'
(at. wgt.)	56	71	= Fe.Cl'
Ferric	Fe	Cl ₃	Cl'
(at. wgt.)	56	106.5	= Fe.Cl'
			Cl

The weight of that part of the molecule which carries the

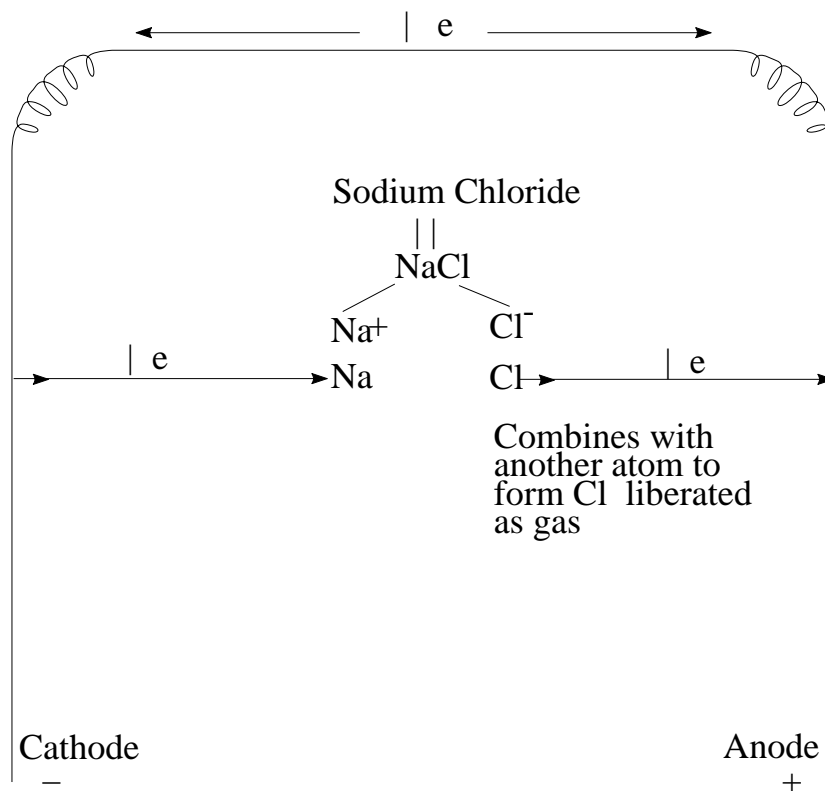


Fig. 7 — Electrolysis of Sodium Chloride

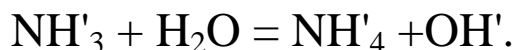
negative charge is increased and so the positive valency of the iron radicle is increased, consequently it is oxidised.

Acids and Bases show similar characteristics. Lapworth in 1908 defined a base as a substance which unites with a hydrogen ion. In other words, an acid is a donor of protons, whereas a base is an acceptor of protons. All acids have this common property, but it may not always hold good for bases.

A neutral ammonia radicle may accept a proton to form an ion and so function as a base:



The ammonia ion can obtain protons from water:



This shows the comparatively greater power of ammonia to act as a base by the resulting appearance of OH' ions, i.e. alkalinity.

It can now be seen that many chemical changes are brought about by an exchange of electrons. Kendal (1929) likens metals to spendthrift males with "money to burn" (electrons to donate), and non-metal to receptive females always ready to do a "spot of gold digging" (wishing to acquire electrons).

Ionised sodium (male) or metal radicle becomes positive, having lost one electron, while chlorine (female) or non-metal radicle becomes negative, having received an extra charge.

Electrolysis, or the passage of electric current through water, again demonstrates the transference of electrons. In a solution of sulphuric acid (H_2SO_4) the positively charged part of compound H''_2 goes to the negative pole or cathode and the negatively charged part SO''_4 goes to the positive pole or anode. In polar compounds the positive part is nearly always a metal. Non-metals may, however, enter the positive radicle, but they only do so in association with other atoms in groups which imitate metals in their chemical properties, e.g.. NH_4 . The negative radicle may sometimes be a single non-metal and sometimes a group of non-metals. In most reactions of this type positive valency equals negative valency.

The electrionic conception of matter was really a progressive development of thought. The old visualisation of a current flowing from the positive pole to negative pole was not really accurate. The "flow" is now held to be a stream of electrons which move or are given off from the negative pole, and go to the positive pole via the liquid in which the electrons are immersed.

Sir William Crookes, who developed the X-ray or vacuum tube, proved that the rays are composed partly of electrons which are shot off from the negative electrode or cathode. Röntgen, in 1895, discovered that bodies obstructed these rays in accordance with their atomic weights, notably that the heavier the weight of the material the greater was the obstruction. He also discovered that X-rays had photographic properties and behaved in a manner somewhat similar to light rays but with apparently a very much shorter wave-length. These electrons or cathode rays possess a mass of about 1/1850th that of the hydrogen atom. From this it can be seen that, as the number of atoms in one gramme of hydrogen is 60.000 trillion, this figure multiplied by 1850 would show that it would require well over 1000 quadrillion electrons to weigh one gramme.

Electrons are now considered to be units of negative electricity, and they may pass between atoms when they react.

In electrolysis the negative wire is teeming with electrons which the cathode has a desire to acquire. Once more we see evidence of Aristotle's Doctrine of the Mean and the tendency of Nature to neutralise excess and deficiency. As the path of virtue is best in Nature, the ions in solution help to bring about the equalisation of the two extremes

For example, consider ionised sodium chloride in water (fig. 7):

The Na has lost an electron and has become Na^+ (Na').

The Cl has gained an electron and has become Cl^- (Cl')

These are attracted to the pole with the opposite charge. The chlorine ion goes to the positive pole, where it gives up its electron and probably combines with another atom in the form Cl_2 , which is liberated as a gas and bubbles off the anode. The sodium ion, on the other hand, wishing to gain an electron goes to the negative pole where a different reaction takes place, which

will be discussed fully later when considering the electro-motive series.

The positive valency represents the number of electrons which may be lost by an atom or group of atoms. The negative valency' represents the number of electrons which can be gained by an atom or group of atoms. The third type of valency is seen in non-polar compounds, which are neither acids, bases, nor salts, and do not conduct electricity when in solution. These are for the most part composed of non-metal groups, e.g. CH₄, CO, CS₂. These radicles share electrons in pairs and are called covalent. The border line between the different types of valency is very indistinct, as many compounds act differently according to their environment. For example, pure sulphuric acid is a poor conductor but is readily ionised in water, when it makes a good conductor.

The Energy of Chemical Reaction may be demonstrated in many ways. For example, if finely powdered aluminium be disturbed with a jet of oxygen and ignited, there results a very violent explosion, which unless great precautions are taken will burst the container:



Again. in the manufacture of water-gas, by passing steam over coke, heat is absorbed; and unless heat is continuously applied the coke will cool until no reaction takes place:



The energy of chemical reaction need not, however, be always shown as heat. A rod of zinc placed in sulphuric acid will produce heat as it dissolves. But if a wire is run from the zinc to a galvanometer and then to a platinum electrode which is also placed in the acid, electrical energy is produced as shown by deflection of the needle. The action of zinc and acid will be considered in some detail later.

The practical importance of this energy production is noticeable in everyday life. Frequently, in making a purchase, we require the resultant energy and not the chemical reaction. Coal is not bought just to watch it alter chemical form, we require the heat produced by combustion. Likewise petrol, flash-lamps, gas, electricity, and many other commodities in use today are useful for their energy and not for their chemistry.

Benjamin Thompson of London in 1798 was the first to deny that heat was a substance. He suggested that it was a form of motion excited by friction. He based his assertion on the enormous heat he had noticed to be produced during the boring of cannon in Russia during the wars. About forty years later Joule, in Manchester, suggested that energy was transformed but not lost. For this effect to be completely proved it was necessary to imagine an isolated system, a state of affairs difficult to apply practically. This theory eventually developed into the Law of Conservation of Energy.

Let us now examine this question of energy of reaction a little more closely. Hydrocarbons, which are formed with the evolution of heat, are extremely inactive chemically. Elementary substances, e.g. nitrogen, are assumed to contain little energy on account of their inertness, and they require energy to be supplied before combining. Nitrogen and oxygen do not usually react at ordinary temperatures. In an arc flame, however, they will form small quantities of nitric oxide. The majority of explosives are nitrogen compounds and are reactive on account of the great ease with which they can release energy by relapsing into a low internal energy level of their constituents.

Chemists were accustomed to explain these combinations by the inadequate word "affinity" -- which word was more useful as a cloak for ignorance than as an explanation of a mysterious happening. Combination, decomposition, and displacement of atoms are brought about by a change or changes in position in the outer shell of electrons, while the interior shell or nucleus is

apparently unaffected. Some atoms give, some take, and some share electrons. Each rearrangement, however, entails a change in the internal energy of the atoms. Work must be done or expended in moving electrons to a new formation. In other words, chemical change, which involves energy transference, probably results in a definite increase or decrease of size of electron orbits.

The **Heat of Formation** gives a quantitative measure of the energy required for chemical reaction. *Note.* -- A chemical calorie equals the average quantity of heat required to raise one gramme of water one degree of temperature between 0°C and 100°. A food calorie is 1000 times this amount. Below are given a few heats of formation:

Sodium fluoride	109,300	calories.
Sodium chloride	97,000	„
Sodium bromide	85,800	„
Sodium iodide	69,100	„

These figures suggest that different combinations have more or less associated energy; in other words, it is easier to combine certain atoms than others, or alternatively they have a greater affinity for each other. Incidentally the smaller the atom the greater the heat quantity required.

Which thought brings us to the, **Electro-motive Series**. This is the order in which atoms tend to displace others from compounds. The following table gives the metals in order of decreasing activity from the top downwards. All above hydrogen will give an electron to hydrogen with increasing power as the list is ascended.

Electro-motive Series of Metals (Partington 1930).

Potassium
Barium
Strontium
Sodium
Calcium

Magnesium
Aluminium
Manganese
Zinc
Chromium
Iron (Fe^{II})
Cadmium.
Thallium
Cobalt
Nickel
Tin (Sn^{II})
Lead
Iron (Fe^{III})

HYDROGEN.

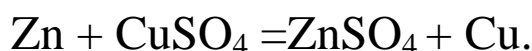
Antimony.
Bismuth.
Arsenic.
Copper (Cu^{II})
Mercury (Hg^{II})₂
Silver.
Palladium.
Platinum.
Gold

To understand the relative importance of this list it will be necessary to revert to the study of electrolysis (fig. 7) and consider the reaction at the cathode or negative pole which was at that time omitted. The Na⁺ was attracted to the negative pole to receive an electron, which is immediately pounced upon by a more greedy hydrogen ion from the water which evolves as gas H₂. Each hydrogen atom liberated leaves a hydroxyl ion (HO⁻) in solution, which now combines with the excited or nascent sodium ion which has had its electron purloined by the hydrogen ion. This leads to the formation of sodium hydroxide or caustic soda, and indeed it is by such a method that this alkali is

produced commercially in large quantities at Niagara, where electricity is cheap.

A similar action ensues when using any salt of a metal above hydrogen in the list. The salts of metals below hydrogen do not so readily combine with the hydroxyl ion and so are deposited or plated on the electrode. The more active metals or impurities, however, remain in solution. The metals at the foot of the list are easily displaced from solutions of their salts by those of metals higher up, consequently this difference of electric potential can be used for recovering traces of valuable metals from solution.

Consider for moment a zinc rod immersed in a solution of copper sulphate. The zinc dissolves and copper is deposited on the surface:



Both atoms are divalent, and so zinc gives to copper two electrons on the change over. This briefly is the principle of the Daniell Cell and gives a voltage of 1.1. If we substitute for zinc a metal lower in the list, say tin, a lower voltage is obtained. On the other hand, substitute for copper at the other pole a metal lower in the list and a higher voltage is produced. The list is therefore named the Electro-motive Series of Metals.

Similarly there is a list of non-metals which shows the order of attraction of the atom for electrons. An element lower in the list will displace one higher from its polar compounds. The order of activity is as follows:

Sulphur.

Iodine.

Bromine.

Oxygen.

Chlorine.

Fluorine.

Hydroxyl (OH)

Sulphite radicle (SO_3),

The active metals are more difficult to isolate and to keep out of chemical combination. Potassium and sodium must be kept in petroleum to prevent oxidation. Lower down the list there is an increasing tendency to stability. At the bottom of the table the metals do not oxidise directly and therefore do not tarnish in air; their oxides are unstable and decompose readily when heated. At the top the reverse is the case. These oxides are very stable to influences which upset those on the opposite end of the list; for example, quicklime cannot be decomposed by heat, electrolysis is necessary. The value of noble metals lies in their inertness, passivity, and permanence. Copper, tin, and iron share these characteristics to a lesser degree, and as they are cheap have many uses in commerce. Reading the list of metals from the bottom gives the approximate historical order of discovery. Those which were easily separated were naturally the first to be found, whereas those difficult to recover from their compounds were only obtained in later years with difficulty.

Another indication of the activity of an atom is valency, and this is usually measured by the number of hydrogen atoms which will unite with one atom of the element in question. It may be seen that this is really a development of the Law of Multiple Proportions, and it is necessary to refer to the Periodic Table (Fig. 4) to observe the import of this arrangement. There are in all nine periods, eight of which are denoted by a Roman figure and the last column by an O. The valency of the elements in these columns is indicated in the horizontal column at the top, and it will be seen that this gradually increases from one to eight with an O on the last column for the inert gases. This sequence is the positive valency. The negative valency runs backwards from the seventh group and gives an alternative valency of -1 to -4 in group 4. An element, however, may or may not use its full valency according to its environment.

Univalent Elements.—The first group (*a*) form oxides which give strongly alkaline solutions when dissolved in water and have a positive valency of 1 (Li_2O , Lithium oxide). Hydrogen, as we have seen, can be either positive or negative. Likewise nitrogen in nitrous oxide (N_2O), silver, copper in cuprous compounds (Cu_2O) gold in AuCl and Au_2O ; mercury in group II can also have a single valency in mercurous compounds (Hg_2Cl_2 and Hg_2O).

Divalent Elements.—Group II (*a*) contains the alkaline earths, whose oxides (BeO_2 etc.) dissolve, not too readily, in water, giving alkaline solutions. Section (*b*): Zinc, cadmium, and mercury in mercuric compounds (Hg_2Cl_2 , HgO). (VI) (*b*): Oxygen and sulphur in H_2S (sulphuretted hydrogen). Nitrogen (V) in nitric oxide (NO). Tin (IV) in stannous compounds (SnCl_2 , SnO), lead in plumbous compounds (PbCl_2 and PbO). Iron (VIII) in ferrous compounds (FeCl_2 , FeO), platinum in platinous compounds. In fact a large number of elements are divalent.

Trivalent Elements.—Group III: Boron a non-metal. Aluminium (V) (*b*) nitrogen in NH_3 , phosphorus in PH_3 and PCl_3 . arsenic in AsH_3 , AsCl_3 , As_2O_3 . antimony, bismuth. Gold (I) (*b*) in AuCl . Iron (VIII) in ferric compounds (FeCl_3 , Fe_2O_3).

Quadrivalent Elements.—In the fourth group there is less harmony. Carbon in CO_2 , silicon in SiO_2 (silica), tin in stannic compounds (SnCl_4 , SnO_2), lead in plumbic compounds (PbCl_4 , PbO_2). Nitrogen (V) in nitrogen peroxide (NO_2), sulphur in SO_2 . Chlorine (VII) in ClO_2 . Platinum (VIII) in platinic compounds.

Quinivalent Elements.—Nitrogen, phosphorus (P_2O_5), arsenic, antimony in higher halogen and oxygen compounds (N_2O_5), PCl_5 , As_2O_5 , SbCl_5). Chlorine (VIII) in chloric acid (HClO_3) and chlorates.

Hexavalent Elements.—Group VI: Sulphur in SF_6 and SO_3 , tungsten, manganese in the trioxide (MnO_3) and manganates (KMnO_4).

It should be noticed that the negative valency is becoming more pronounced as we ascend the groups.

Heptavalent Elements.—Group VII: contains the halogens and one undiscovered radio-active element with atomic number 85. Chlorine in Cl_2O_7 (heptoxide), iodine in periodates (KIO_3), manganese (a) in Mn_2O_7 , and permanganates (KMnO_4).

Octavalent Elements.—Group VIII: Osmium in OsO_4 and OsF_8 , ruthenium in RuO_4 .

The lowest valency is shown in hydrogen compounds and the highest in compounds of oxygen.

Compounds of the same element, where a different valency is exerted, have usually totally different properties. This is due to the number of outer electrons in the shell, which is the basic factor in chemical reaction and activity.

Zero Valency Elements.—These are in the 0 group and consist of inert gases and certain radio-active emanations. They are zero valent, as, having their outer shell of eight electrons completed, they cannot take part in ordinary chemical reactions.

Let us now investigate generally the arrangement of the elements in the Periodic System. First we have Series 1 with hydrogen and helium. After this, follow two periods, 2 and 3, with eight elements in each. These in turn are followed by three long periods of seventeen elements but only part of a fourth. Each of these long periods can be further divided into seven elements, a group of three, and a further group of seven. In the sixth period, however, there is a difficulty, fifteen rare earth elements are placed in one compartment; this anomaly will be cleared later when the Bohr arrangement is discussed.

The valency changes in the short periods are in general similar to those of the long periods. The first three elements in the long periods (potassium, rubidium, and caesium) resemble the first two in the short periods (lithium and sodium), alkali metals. Eleventh in the long periods are silver, and gold; they have a resemblance in their own group, but are only similar to

the alkali group in having a positive valency of one.

Chemistry, like, medicine, has been the result of intensive specialisation, with the result that an important factor has been somewhat neglected. In chemistry we know too little about the transference of energy by moving the electron in its orbits and out of them. In medicine we know far too little about health and the early deviation therefrom. So much of the study has been about advanced disease.

The second elements of the long series (calcium, strontium, barium) are similar. The twelfth elements (zinc, cadmium, and mercury) are also similar, but the only feature in common between six elements is a positive valency of two.

And so on, progressive similarities can be traced between the groups.

The three transitional elements between the two groups of seven are always metals of almost identical character, e.g. (Group VIII) iron, cobalt, and nickel. The maximum valency of these is eight, although this is not always shown. Throughout the scale there are, of course, minor parallel differences, but the first in one series resembles the first in another, the second is alike to the second of another, and so on.

Mendeléeff suggested that the apparent errors in the arrangement were not due to imperfections in his system but to faulty atomic weights. He did not hesitate to move his elements about in the table to make them harmonise. Later and more accurate work proved his reasoning to be sound. In fact he prophesied several other elements according to their properties, which, when found, corresponded to his forecast in an amazing manner. To-day the table is complete except for the two elements with weights 85 and 87 and, of course, those, if any, above uranium (92). The inert gases in the 0 valency column can be taken as stable links between the active non-metal and active metal. For example, argon forms a neutral link between chlorine and potassium. At this point of the progressive

scale there appears to be a complete extinction of chemical activity. The outer shell of eight electrons is complete and the atoms remain monatomic, that is, they do not join to form molecules like other gases.

We must now leave the descriptive details of the elements and their behaviour, to consider in the next chapter how the elements are in turn composed of more minute particles, the exact comprehension of which is almost at the limit of our mortal senses.

For the reader's convenience, however, there follows a list of the known elements in alphabetical order, giving their atomic characteristics and symbols.

[TABLE

	Symbol	Atomic Number	Atomic Weight
Actinium	Ac	89	226.0
Aluminium	Al	13	26.97
Antimony	Sb	51	121.77
Argon	Ar	18	39.91
Arsenic	As	33	74.96
Barium	Ba	56	137.37
Beryllium	Be	4	9.02
Bismuth	Bi	83	209.0
Boron	B	5	10.82
Bromine	Br	35	79.916
Cadmium	Cd	48	112.41
Caesium	Cs	55	132.81
Calcium	Ca	20	40.07
Carbon	C	6	12.0
Cerium	Ce	58	140.25
Chlorine	Cl	17	35.457
Chromium	Cr	24	52.1
Cobalt	Co	27	58.94
Columbium (or Nyobium)	Nb	41	93.1
Copper	Cu	29	63.57
Dysprosium	Dy	66	162.52
Erbium	Er	68	167.7
Europium	Eu	63	152.0
Fluorine	F	9	19.0
Gadolinium	Gd	64	157.26
Gallium	Ga	31	69.72
Germanium	Ge	32	72.6
Gold	Au	79	197.2
Hafnium	Hf	72	178.6
Helium	He	2	4.0
Holmium	Ho	67	162.4
Hydrogen	H	1	1.008
Illunium	Il	61	147.0
Indium	In	49	114.8
Iodine	I	53	126.932
Iridium	Ir	77	193.1
Iron	Fe	26	55.84
Krypton	Kr	36	82.9

	Symbol	Atomic Number	Atomic Weight
Lanthanum	La	57	138.9
Lead	Pb	82	207.2
Lithium	Li	3	6.94
Lutetium	Lu	71	175.0
Magnesium	Mg	12	24.32
Manganese	Mn	25	54.93
Mercury	Hg	80	200.65
Molybdenum	Mo	42	96.0
Neodymium	Nd	60	144.27
Neon	Ne	10	20.2
Nickel	Ni	28	58.69
Nitrogen	N	7	14.008
Osmium	Os	76	190.8
Oxygen	O	8	16.0
Palladium	Pd	46	106.7
Phosphorus	P	15	31.027
Platinum	Pt	78	195.23
Polonium	Po	84	210.0
Potassium	K	19	39.096
Praseodymium	Pr	59	140.92
Radium	Ra	88	225.95
Radon	Rn	86	222.0
Rhenium	Re	75	187.0
Rhodium	Rh	45	102.91
Rubidium	Rb	37	85.44
Ruthenium	Ru	44	101.77
Samarium	Sm	62	150.43
Scandium	Sc	21	45.1
Selenium	Se	34	79.2
Silicon	Si	14	28.06
Silver	Ag	47	107.88
Sodium	Na	11	22.997
Strontium	Sr	38	87.63
Sulfur	S	16	32.064
Tantalum	Ta	73	181.5
Tellurium	Te	52	127.5
Terbium	Tb	65	159.2
Thallium	Tl	81	204.39
Thorium	Th	90	232.15

	Symbol	Atomic Number	Atomic Weight
Thulium	Tm	69	169.4
Tin	Sn	50	118.7
Titanium	Ti	22	47.1
Tungsten	W	74	184.0
Uranium	U	92	238.17
Uranium-X	U-x	91	234.0
Vanadium	V	23	50.96
Xenon	Xe	54	130.2
Ytterbium	Yb	70	173.6
Yttrium	Y	39	88.9
Zinc	Zn	30	65.38
Zirconium	Zr	40	91.0

CHAPTER IV

PICKING THE ATOM TO PIECES

The present detailed knowledge possessed by science about the intimate structure of the atom has been obtained for the most part by the study of radio-active substances and spectrum analysis. In 1896, Professor Henri Becquerel of Paris first noticed the radiation from salts of uranium and their effect on silver bromide (photographic plate). He also studied their effect on a charged electrometer, which was discharged when the salt was held near it owing to ionisation of the air in the vicinity. In the same year Schmidt and Mme Curie discovered similar properties associated with compounds of thorium. Two years later Mme Curie isolated radium from pitchblende. First she prepared a salt similar in many respects, to barium sulphate. From this she produced a substance free from barium which was more than one million times as active. This was radium bromide, the form which is frequently used in medicine to-day for curative purposes.

The difficulty of preparing radium can be judged from the fact that a ton of ore yields less than ten milligrammes of the radium salt.

The action of radio-activity can be studied by three methods:

(a) Photographic or similar to X-ray in effect.

(b) phosphorescence produced by the action of rays on platinocyanides, zinc silicate, zinc sulphide, and calcium tungstate (which latter is largely used in X-ray intensifying screens of to-day).

(c) Ionisation of gases as shown by the gold-leaf electroscope

Radium emits three kinds of rays, which are affected as follows by an electro-magnetic field:

a (alpha) rays are positively charged, are bent in one direction.

b (beta) rays are negatively charged, are bent the other way.

γ (gamma) rays are unaffected.

Alpha rays have since been shown to consist of helium atoms ejected with velocities according, to the nature of the salt producing, them. Their speed (about one twelfth that of light) and large mass gives them a high kinetic energy. They each carry a double positive charge, having lost two electrons. Each alpha particle detaches one electron from each molecule of gas it ionises. The liberated electrons drop back on the atomic shells, and this condensing or resulting decrease of electron orbit causes a radiation to take place in the form of light or heat. An alpha particle from RaC' can ionise 237,000 molecules in its passage through air. The heat evolved from radium is over 130 calories per gramme per hour, which fact may give some idea of the enormous potential energy lying more or less dormant in the the atom of radium.

Beta rays are particles, or electrons, or units of negative electricity shot out with a velocity approximating that of light, i.e. 300,000 kilometres per second. In an electromagnetic field they can be deflected as much as 180° . Owing to their small size and greater velocity they can penetrate matter to a greater degree than alpha particles. For the same reason they are deflected from their course in a greater measure on impact with individual atoms. The ionisation produced in gases results in knocking one electron off a molecule of gas, thus leaving a positive ion. This effect, however, is relatively smaller than that of the alpha particle. Helium atoms are stopped by a sheet of brown paper or a sheet of aluminium foil one-hundredth of a millimetre thick, whereas electrons can penetrate gold-leaf but

are stopped by a piece of aluminium plate one centimetre thick.

Gamma rays are identical with X-rays and are probably produced by the bombardment of electrons on surrounding matter. They can penetrate relatively thick layers of metal or other materials.

In 1902, Sir Ernest Rutherford and Frederick Soddy working at McGill university, Montreal, decided, after many experiments, that the radio-active effect observed was brought about by a spontaneous disintegration of the heavy nucleus into atoms of other elements. It is to-day generally recognised that radium disintegration results in helium and radon, both chemically inert gases. There is then a further breaking-up of radon into a series of elements which finishes with an isotope of lead. There is no doubt about these substances being elements, as they fit definitely into the periodic scale, and they have their own places in the spectrum series of the elements. So far no chemical means has been devised capable of accelerating or diminishing the speed with which these radio-active elements break up. This rate is unaffected by changes of temperature, chemical reagents, or any other means at present known. Which fact is made use of as a means of distinguishing radio-active elements, which are often indicated by their disintegration time. The number of atoms of a given mass splitting up at a given time is constant, consequently the lives of these elements can be calculated. They are known by their average lives or half periods, which vary from a very small fraction of a second to many millions of years.

These measures can be ascertained by means of the Crookes' Spintariscope (fig.8), which consists of a powerful lens (A) and a screen (C) covered with zinc blende (sulphide) and a small particle of known weight of the radio-active substance (B). If in a dark room the eyes are allowed to rest thoroughly for fifteen minutes to an hour, flashes can be seen as the helium atoms strike the screen. The distances, weight of material, and number

of flashes being known, the speed of disintegration is reduced to mathematical calculation. The luminous glow on the hands and figures of a watch, which can be seen in a darkened room

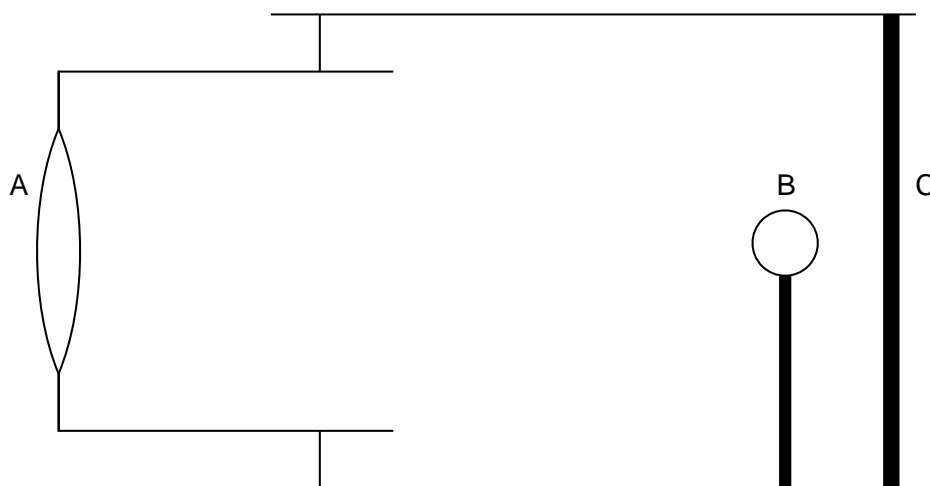


Fig. 8.—Spintariscope (Crookes').

with a pulsating glow, is a similar phenomenon and is probably as near as can be reached, by the naked eye, to seeing a single atom.

Rutherford's further experimental work proved that other elements could also be broken up. He was able to disintegrate nitrogen and aluminium by exposing these elements to rays from radium-C (helium atoms). The product of disintegration was partly hydrogen atoms.

The fact that elements are capable of transmutation in certain cases into other elements introduced the difficulty of defining what is meant by the words atoms and elements. Previously these expressions were taken to indicate the utmost limits in the subdivision of matter. The ever-changing conceptions of science have now made this definition one of difficulty. The alchemists, as we have seen, resolved matter into four forms — earth, air, fire, and water. Early chemists used to call anything they were unable to divide an element, but this was obviously unsatisfactory. In 1815, William Prout, an English physician, suggested that all elements were aggregates of hydrogen atoms. Which idea, based on the assumption that the atomic weight of hydrogen = 1, was not well received by scientists, although quite

a number of elements have atomic weights which are integers.

The number of integers is still greater when the basis of the scale is that of oxygen =16. Sir William Ramsay, on full examination of all details, decided that the odds were many million to one against this fact being accidental. At the same time no scale of atomic weights gave integers to all elements, and this was the obvious requirement to bring the whole matter into line. Eventually, however, radio-activity gave the answer.

Beta rays or electrons are the same whatever the source. Kendal (1929) indicates that on the oxygen scale they have a mass of .000,54. As atoms are electrically neutral they must be composed of something else besides units of negative electricity. Therefore it is assumed that units of positive electricity must also exist. These, however, have proved not quite so easy to investigate as they are the very tiny particles which exist at the centre of the atom and do not usually take part in chemical change. They are called "protons", from the Greek, meaning first. They have a mass of 1.007. The atomic weight of hydrogen, by the way, is 1.0078.

Atomic structure was studied by Sir Ernest Rutherford in 1911. He suggested that the basic form of atomic structure was a small central nucleus surrounded by planetary electrons at a relatively great distance. The formation of the atom was then similar to our own planetary system revolving around the sun. This central nucleus contains all the positive units or protons and is responsible for almost the entire mass of the atom. The external electrons are responsible for the volume. Ordinary chemical changes are brought about by changing the position of the outer electrons. It is only in radio-active changes that the nucleus is modified.

The scale of atomic weights presented certain difficulties. Lead from ordinary sources is always 207.20; but some samples from the pitchblende mines in Bohemia, tested by Professor

Theodore W. Richards of Harvard University in 1914, gave an atomic weight as low as 206.65. Soddy found that specimens taken from the thorium series were as high as 208.4. Yet the extraordinary finding was that all these pieces of lead behaved in an identical manner chemically. If this fact could be explained it would throw new light on Fractional atomic weights, e.g. chlorine 35.457 and others.

In the Mendeléeff system the order of atomic weights is disregarded in some cases. Argon (39.9) comes before potassium (39.09); cobalt (58.9) comes out of order with nickel (58.7); tellurium (127.6) comes before iodine (126.9). Mendeléeff placed the elements in order of properties, and explained these anomalies by saying that the then known-weights were not strictly accurate. This statement, however, was not satisfactory, neither was it very helpful. The next question was naturally to find some way of indicating the arrangement of atoms which would obviate these difficulties.

Atomic Numbers were suggested by H.G.V. Moseley a few years before the Great War. Unfortunately his researches were cut short by his death at Gallipoli. If the anti-cathode of a Crookes' tube be coated with various elements, X-rays of different wave-length are produced when the current is passed. The spectra of these elements when analysed show two dark lines in two graded series according to the arrangement of elements as given in the Periodic Table. These lines are designated K (hard) and L (soft). Moseley used a crystal of potassium ferrocyanide to get his X-ray reflections. These did not agree in all cases (marked * in fig. 4) with atomic weight, but did, however, with the order of arrangement.

On purely theoretical grounds Moseley showed that the position of these lines depended on the electronic structure of the atom. The greater the positive charge on the nucleus the shorter is the wave-length of the X-ray produced. From this it was found that if the elements were arranged in order of the

Periodic Table, they could be given successive whole numbers, which are inversely proportional to the square root of the wavelength shown in the corresponding X-ray spectra. Starting with hydrogen as number one, all known elements fit this law. The

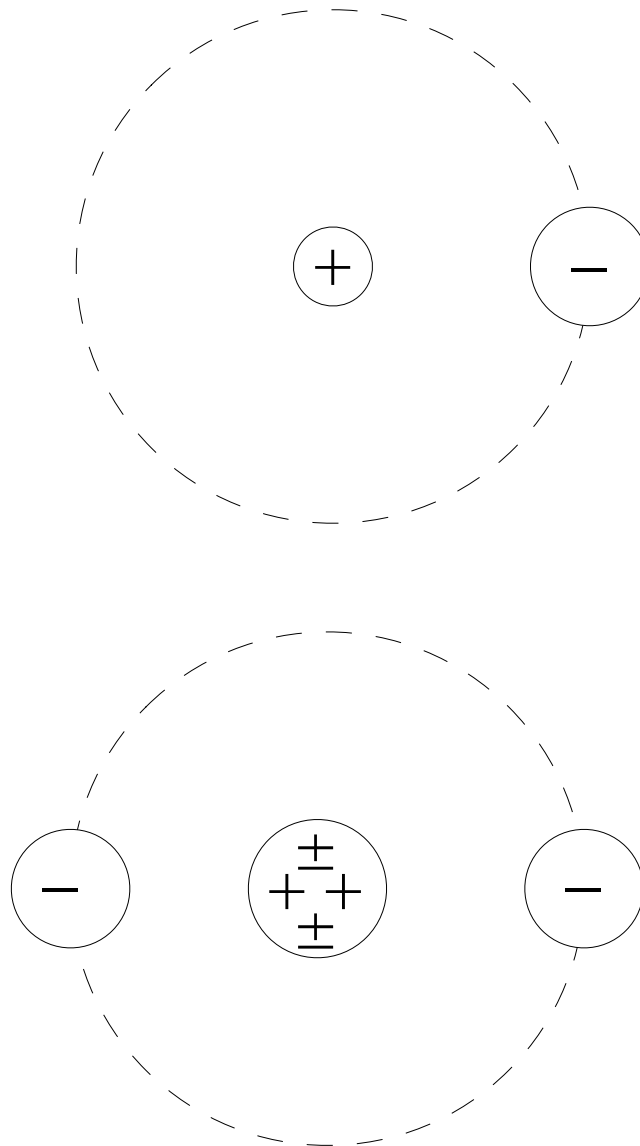


Fig. 9. — Hydrogen (above) and Helium (below) Atoms.

system, therefore, is now indexed in order of increasing nuclear charge. The atomic numbers, in consequence, determine all the properties of the varying elements.

A glance at fig. 9 will indicate diagrammatically the basic conception of the atom. At the top, hydrogen (atomic number 1) consists of one proton one electron — probably revolving or oscillating rapidly in an orbit at a very great relative distance.

The speed of the electron travel, if assumed to be corpuscular in its orbit, probably approximates that of light. The orbit shown in the diagram is in two dimensions and circular, but it is more probably three-dimensional and may not be spherical. Helium (atomic number 2 and atomic weight 4) is assumed to have a nucleus with bound protons and free protons. Bound protons are associated closely with electrons and are termed neutrons. The alpha particle previously described consists of the helium nucleus stripped of its electrons. The total four protons explain why helium is approximately four times the weight of hydrogen.

There is accordingly a similar progressive state for other elements. The number of free protons in the nucleus is represented by the atomic number. Since the atom is neutral, external electrons must equal the number of free protons. The number of bound protons is equal to the difference between weight and number, e.g. sodium: atomic weight =23, atomic number is 11, therefore nuclear charge is 11; consequently the nucleus contains 23-11, or 12 bound protons. Finally there are 11 external electrons to make up neutrality.

Fractional Atomic Weights Explained.

We are now in a position to solve certain difficulties which have already been pointed out by Mendeléeff when he disregarded certain atomic weights in his table. In radio-active disintegration an atom losing a helium ion also loses two free positive charges, thus reducing its atomic number by two — radium =88, radon = 56. Radio-active changes involving the loss of one electron result in one positive charge in the nucleus being set free but not thrown off, and the number is increased by one. A number of these compounds occur where uranium disintegrates, and are known as isotopes. A number of the common elements also consist of isotopes in various proportions.

Positive rays pass through a Crookes' tube in the opposite direction to cathode rays. These were shown by Sir J. J.

Thompson to be atoms which had lost electrons, in other words nuclei or protons, or possibly ions. By introducing various elements into the tube, these rays can be obtained from different sources. The apparatus for doing this is shown diagrammatically in Fig. 10 and is known as the Aston's Mass Spectrograph. The positive rays from the Crookes' tube are passed through two slits to produce a narrow beam as shown by the dotted lines. They are then deflected by two condenser plates with respectively positive and negative charges; the rays being

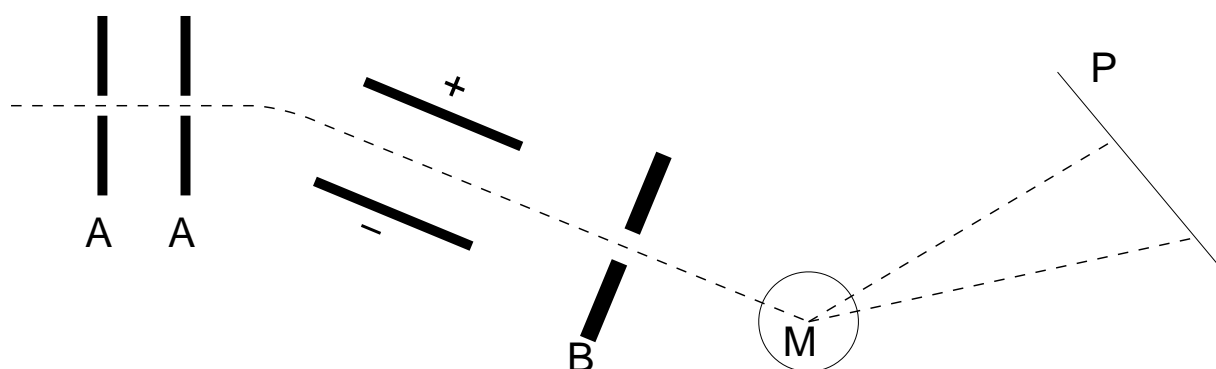


Fig. 10 — Aston's Mass Spectrograph.

positive are naturally bent towards the negative plate. They then pass through another slit (B), after which an electro-magnet (M) bends them back again. The amount of bending back varies for different masses and is shown by lines on a photographic plate (P). From various measurements in the apparatus and the position of the bands, the mass of the atoms can be calculated.

From this investigation it was discovered that chlorine (35.457) was composed of two isotopes 35 and 37; bromine (79.916) of 79 and 81, argon (39.91) mostly 40 with a trace of 36; potassium (39.096) was 39 with a little 41. The light species of potassium is therefore lighter than argon. Thus the explanation of certain irregular atomic weights in the system shows that the elements are composed of varying proportions of their isotopes, giving resultant weights which are the averages of two or more integers. Oxygen, nitrogen, and iodine gave no isotopes.

To clarify the matter still further, consideration of the

construction of isotope atoms is now necessary. Chlorine for example is:

	<i>Nucleus.</i>	<i>Exterior shell</i>
Cl 35	$\left\{ \begin{array}{l} 17 \text{ free protons.} \\ 18 \text{ bound protons.} \\ 18 \text{ electrons.} \end{array} \right.$	17 electrons.
Cl 37	$\left\{ \begin{array}{l} 17 \text{ free protons.} \\ 20 \text{ bound protons.} \\ 20 \text{ electrons.} \end{array} \right.$	17 electrons.

The chemical behaviour depends on the nuclear charge which is equal to the number of exterior electrons normally carried by the atom. The outer electrons make a relatively small difference in the weight of the substance. Chemically some of these isotopes have been separated, but they have no industrial value as yet.

All matter is now reduced to a basis of protons and electrons. The manner in which the transmutation of elements could be arranged is therefore obvious, although as yet it is not possible to apply these principles in a commercial way. Verily the atom is picked to pieces and another chemical misnomer is exposed. The word atom, meaning indivisible, is far from being applicable in the strictly accurate meaning of the term.

Atoms of same element may now have different masses, also atoms of different elements may have the same mass, which later are known as isobares. These have not, however, the same chemical properties, owing, to different number of external electrons. The definition of an element at this stage takes on a more simple form. An element contains atoms of the same atomic number or nuclear charge. Likewise chemical compounds consist of atoms of different atomic numbers in simple ratios.

If radio-active elements could be induced to accelerate their disintegration, an enormous source of power would be available from atomic energy. We have seen that radium evolves over

130 calories per hour, and this production of energy continues for centuries,. The total heat evolved during that time is well over 2,000,000,000 calories per gramme.

In contrast, one gramme of carbon burning to carbon dioxide gives only 8070 calories. One pound of uranium evolves enough energy to propel the Queen Mary across the Atlantic - but it would take about five billion years to do so. Incidentally it has been suggested that the heat of the earth has been maintained, partly at least, by radio-active emanations from its interior, because it seems that the heat from the sun would not be sufficient to maintain such a steady temperature even allowing for the high internal heat assumed to exist.

Atomic Energy must now be considered in some detail. On examination of fig. 9 it is obvious that the atom of helium contains exactly the same units as four atoms of hydrogen. Yet the mass of helium is not $4 \times 1.008 = 4.032$, it is 4. Therefore 0.032 units of mass have been lost in the rearrangement of the atoms. The loss in mass is equal to the evolution of energy. *Matter is potential energy, and energy is probably potential matter.* The transmutation of one gramme of hydrogen to helium would liberate 166,000 calories or 200,000 watts.

Having detailed the theoretical side of the structure of the atom it might be well to get its form well fixed in the mind by a rough example. Imagine a motor-car travelling round Brooklands track with a speed approximately that of light. The nucleus might roughly be represented by a bee sucking honey from a flower in the centre of the group circumscribed by the track. This inaccurate analogy may give some slight idea of how difficult it would be to hit the aforementioned bee with a machine-gun bullet at a range of several hundred miles. The alpha rays and the nucleus are relatively so small that only one in many millions can hit the target or nucleus. Herein lies the fundamental difficulty of splitting the atom.

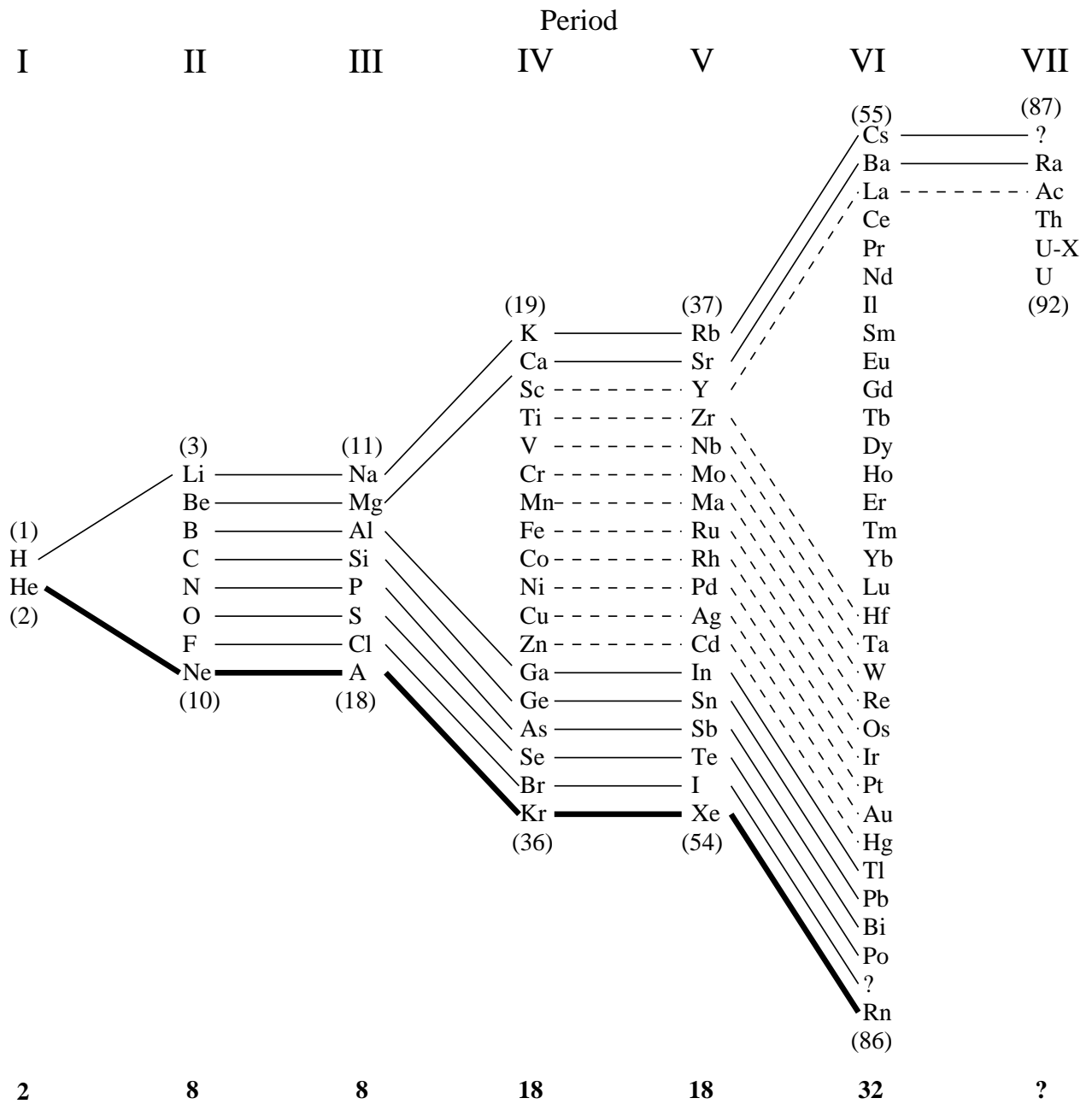
In the very small compass of the nucleus all the protons of

the atom are collected. Theoretically positive units bearing the same charge should repel one another, so it is assumed that the negative units act as a kind of cement. The number of these latter is never less than half the number of protons contained in that atom. As the periodic system is ascended the proportion tends to get a little higher. The congested nucleus of the larger atoms tends to make the cementing more difficult and less stable. Elements of higher atomic weight therefore tend to explode or disintegrate spontaneously; in other words they are radio-active. In hydrogen alone this cementing action is lacking, as this element is the only one that contains a single proton.

Neils Bohr, conscious of the difficulties of the Mendeléeff table, arranged the elements in columns in order of atomic number, concluding each column with an inert gas (fig. 11). The number of the elements in each column when placed in this form was 2-8-8-18-18-32-(?). The fact that this apparently followed a mathematical series $2(1^2 - 2^2 - 2^2 - 3^2 - 3^2 - 4^2)$ seemed too remarkable to have occurred by chance. He then connected with lines those elements with similar properties.

If the electrons were mobile, like planets around the nucleus, the compactness of neon compared with sodium suggested that the outer electron might be easy to displace, from the latter. From these simple foundations he built up the idea of the atom, consisting of a central nucleus with the electrons probably revolving in different layers or shells, and thus developed the corpuscular theory of matter.

In chemical changes outer layers are disturbed; for example, in ionisation of potassium one electron is lost. The shifting of electrons from one orbit to another is supposed to be the origin of radiation, i.e. spectrum lines etc. Bohr calculated, by the laws of dynamics, the energy emitted and absorbed by change of orbital position and found that this was in comparative agreement with the lines on the spectrum.



(Atomic numbers shown in brackets are those of adjacent elements.)

Fig. 11 — Bohr's Arrangement of the Elements

The maximum number of possible electrons in each quantum class followed the mathematical series, and is given by the formula $2n^2$: the outer class of orbit cannot contain more than eight electrons (c.f. Octet Theory), and one next to the outermost, eighteen. From the above, the periods of the Mendeléeff table give the following figures:—

No. of Period	Last Element in Period	Atom. No of Last Element	No. of Electrons in Classes of Orbits						
			I	II	III	IV	V	VI	
1	He	2	2						
2	Ne	10	2	8					
3	A	18	2	8	8				
4	Kr	36	2	8	18	8			
5	Xe	54	2	8	18	18	8		
6	Rn	86	2	8	18	32	18	8	

The rare earth metals were found to fit this scheme too. The seventh column is unfinished, because the elements after uranium (92) are probably too unstable to exist under ordinary chemical conditions. The variable valency of the fourth and other periods can also be explained along these lines. During the change of the inner class of orbits from a stable group of eight electrons to one of eighteen, or from one of eighteen to thirty-two, there occurs a transitional series of elements which can have more than one structure.

Take the third period electron arrangement 2, 8, 8 maximum for argon (atomic number 18); the next element Potassium (atomic number 19) is a typical alkali metal arrangement of 2, 8, 8, 1. Calcium is next with 2, 8, 8, 2. As we proceed further there is a tendency for additional electrons to choose between filling the fourth class (outer shell) to a maximum of eight, or to slip

into third orbit (inner shell) and start to fill that to a maximum of eighteen. So we find alternative electronic arrangements are possible, of which some examples follow :

24. Chromium	2, 8, 13, 1	
	2, 8, 8, 6	chromates
	2, 8, 11, 3	chromic salts.
	2, 8, 12, 2	chromous salts.
25. Manganese	2, 8, 13, 2	
	2, 8, 8, 7	permanganates
	2, 8, 9, 6	manganates
	2, 8, 12, 3	manganic salts.
	2, 8, 13, 2	manganous salts.
26. Iron	2, 8, 14, 2	
	2, 8, 10, 6	ferrates
	2, 8, 13, 3	ferric salts.
	2, 8, 14, 2	ferrous salts.

Chromates, manganates and ferrates are derived from atoms with shells of 2, 8, 8, 6; 2, 8, 8, 6; and 2, 8, 10, 6: all of which which have the same number of outer electrons. This is a somewhat similar formation to that of sulphur (atomic number 16) with shells of 2, 8, 6; hence these salts resemble each other and are like sulphates to some extent.

The rare earths fit this idea by filling up the fourth shell from 18 to 32. This shows how the trivalent system is maintained while the inner ring has a variable number of electrons. Elements with incomplete inner shells are those which tend to give coloured ions in solution. The capacity of compounds to absorb light energy is connected with the ability to allow electrons to slide easily from one orbit to another.

If we could by some means or another drive away all the electrons and condense all the nuclei together, the result would be an enormously heavy mass. Astronomy tells of such an effect. Sirius, the Dog-star, has a companion (like our moon)

which has many thousands of times the density of water. This is very much denser than any of our earthly materials. One cubic inch of the companion to Sirius weighs almost a ton — yet astronomers state that a number of stars are as much as eight times heavier again.

Of recent date, in many national newspapers, appeared headlines about heavy water. Infield (1934) states that hydrogen has an isotope with atomic weight of 2, which only occurs once in tens of thousands of atoms of normal hydrogen. Recently this has been isolated, and gives on combination with oxygen a water distinctly heavier than normal. The full extent of the possibility of this discovery and what, if any, uses it will have in biology is not yet known.

In 1926, Louis de Broglie in France was attempting to apply Einstein's theories to the Bohr atom, and found that in order to get his equations to fit he had to assume that the electron revolving in the orbit was accompanied by a group of waves. That was another step forward in the development of the Theory of Atomic Structure, but it makes it still more difficult to apply ordinary reasoning to the conception of a state of affairs outside our ken.

How can we understand an atom, which is very largely composed of space, when we know that all the objects we see and use every day appear solid? A famous scientist once said that "Wave is the nominative of the verb, to undulate." But we do not yet know exactly what waves really are. They are born behind the electron and die out in front. The image of a red neon lamp seen while the head is in motion from side to side, appears like a wave of this type. The lamp is a solid particle, but we see, it apparently in motion as a wave.

Theoretically an atom can extend into infinite space, but practically this effect is negligible. Waves, flying energy, quanta, or corpuscles are theories, none of which completely explains matter, yet each helps the other to explain the whole.

But it seems once more as if the alchemists of old had the truth within their grasp, but could not quite explain it. They said that phlogiston was something which was lost on burning. When iron rusts it loses electrons. The thought is, therefore, that the phlogiston of the early scientists is really our electron of to-day.

Be that as it may, we can now see that all chemical changes depend on the gaining or losing of electrons. In later chapters we will see how this loss or gain, this excess or deficiency of Aristotle, can be applied to modern biochemistry. We shall see that health is a delicate balance whereby electrons are in the optimum state for the liberation of energy, which state is the best for the maintenance of health and a harmonious functioning of the human body.

CHAPTER V

. . . AND SO AD INFINITUM

At this point in our researches into the hidden mysteries of nature and science it would be well to cast off the fetters of convention and regard matter for a moment in an impartial and unbiased manner. We are so used to examining facts through our personal senses and experiences that it will be difficult, but not impossible, to discard our usual conceptions and attempt to realise truth unclad and undisguised.

Ptolemy once said that the earth is at rest and the sun moves. Copernicus, on the other hand, said that the earth moves and the sun is at rest. Each of these statements is true, yet each is false. First Ptolemy, using his ordinary senses, saw the sun move across the heavens and the earth apparently still. His statement is true, but it is not a complete statement of fact. Copernicus took a broader view, and stated that the sun was stationary; yet modern astronomy teaches that neither of these men spoke the whole truth. Really both the sun and the earth move, each in their respective orbits. Throughout the development of man's conception of matter theories evolve, mature, and are cast aside. Each theory helps as a stepping-stone to greater things, although each taken in the light of latter knowledge was quite erroneous in itself.

When dealing with the energy of atomic construction we see that matter and energy are really different forms of the same thing, but this is difficult to realise in a concrete way. We cannot see energy and we can see matter; to realise that one is synonymous with the other is not easy. The smallest subdivision of matter is a quantum of energy, and owing to its minute size approaches infinity. On the other hand the universe is

apparently part of an immensity which likewise approaches infinity on the other side of the scale. Near these two extremes mathematics may function in a definite manner; but our finite minds are only able to portray the happening in a dim mystic light; we can only understand them dimly when illustrated by allegory and symbolism.

In our earlier days, as unwilling students of mathematics, the idea of infinity conveyed to our developing minds was something just beyond our real comprehension. We could visualise one article, perhaps a dozen pencils, a gross of sweets, or five hundred boys at a school. As a flight of fancy we might have calculated the approximate number of verses or letters in the Bible — but after that the true realisation of quantity was getting rather hazy. And even to-day, with minds more fully developed, it is difficult to visualise the accurate meaning of a very large number. The magnitude of infinity is completely outside the ken of the limited senses of the majority of individuals.

In much the same fashion it is easy to divide an apple into halves or an orange into so many "quarters" — one can imagine one man as a thousandth part of a large meeting — but to really visualise atoms and electrons is a physical impossibility. We can, in practice, only deduce that they may have certain properties and certain forms from the phenomena observed by our comparatively none too accurate instruments. On investigating the properties of certain materials we can only obtain a relative view, and it is of paramount importance to define clearly the exact point of view in assessing results. A New York sky-scraper presents a totally different appearance to a man on the ground from that seen by a man in an aeroplane far above. To a small insect, however, it must possess an immensity unnoticed even by the man on the ground.

In the same manner a number of effects are dependent on environment. An electric storage cell, such as a small

accumulator, will pass, a current from positive pole to

negative pole through an electric circuit. If, however, a power supply is connected to the cell, positive pole to positive pole, the current will be passed through the cell in the opposite direction. In the former case the cell is a supply of electrical potential energy, in the latter it is an acceptor or store for same.

It has been obvious in dealing with the electro-motive series that a metal may be an acceptor of electrons from one metal, and a donor if another metal is used in the system. So, too, can practically any substance be made to absorb or radiate energy in some form or other if certain conditions are produced.

In the cycle of life it is known that carbon dioxide and water are absorbed by plants and synthesised into starches and sugars, giving off oxygen in the process. In this conversion the energy content of the final product is much greater than the combined energy of the former components. This energy is obtained from the sun's rays in the form of light and heat. The animal assimilates the starch and sugar contained in the plant and oxidises them. In doing so it converts to its own use the energy contained therein and throws off the used-up atoms — that is, the atoms deprived of their energy (the CO_2 molecule).

The plant taking $\text{CO}_2 + \text{H}_2\text{O} + \text{energy}$ generates starch and sugar + O_2 . The animal uses $\text{O} + \text{starch and sugar}$ and generates energy + $\text{CO}_2 + \text{H}_2\text{O}$. Thus there is a continuous cycle, which will continue so long as the plant can obtain energy in the form of radiations from the sun.

By some means, the exact details of which are at present unknown to science, the atoms contained in the molecules of CO_2 and H_2O are energised, their electrons are rearranged, and probably there is also some change in their electron orbits as well. This absorption of energy enables the larger compounds of sugar and starch to exist in a comparatively stable state. On assimilation and utilisation by the animal this energy is removed, and the atoms return to their former state; and so life

goes on.

This thought has a deep and far-reaching effect if we apply it to our knowledge of medicine. It has been shown in a previous chapter that in certain conditions the orbits of electrons get bigger as they are energised — that is as energy is loosened — with the eventual disintegration of the electron as energy radiation. In a similar manner, if energy is bound up and condensed in the atom, the orbit gets smaller. Theoretically it is legitimate to suppose that at infinity the orbit becomes so small as to be negligible and so may even become part of the nucleus. This is the sort of formation we find in the bound electrons in the protons. A positive and negative charge are so bound up that they help to make up the mass of the atom, but have no appreciable effect on its volume. It is no great flight of fancy, therefore, to visualise the development of the atomic series by the gradual condensation of energy which is bound up in the nucleus in varying proportion. How this happened we cannot hope to suggest, but it seems reasonable to expect that something of the sort took place many æons ago, and possibly is still doing so.

Each time an electron is removed in its orbit or dissipated as radiation, energy is transferred. Oxidation and reduction are two common forms of this movement of electrons. Consider the relative side for a moment. Suppose a substance A oxidises a substance B. The former will donate an electron to the latter. Therefore A is reduced by B. B is a reducing agent, that is it takes one electron, but after the action A is reduced. The reducer becomes the oxidised and the oxidizer becomes reduced. Further, the substance B could oxidise another substance C, and again we have a similar sequence of events. B we see may either act as an oxidizer or reducer according to the potency of the system with which it is brought into contact. The action can therefore be explained from either point of view. From which it follows that the substance B can be either oxidizer or reducer,

oxidised or reduced; so we realise how necessary it is to have an accurate relative picture to visualise the importance of any statement.

The real importance of this matter must be born in mind in connection with the administration of medicine to the human body, because the result achieved will depend on the state of the electronic activity or condition of the system previous to the administration of the drug. Before dealing with these points in relationship to medication there are still a number of points of chemical interest which have to be outlined.

At this point we may pause to survey the whole range of chemical reaction in this new light notably as being based on one fundamental principle — which is, in short, the transmutation of energy. This process acts in two ways, each the opposite to the other. In the one case we have a gradual tightening-up of the energy towards or in the nucleus — process which has probably progressed further on Sirius than on earth. In the other case there is a distinct loosening of the energy, which may even lead to its eventual dissipation. These two changes in elemental matter are the primary and fundamental bases on which I will later show the phenomena of material life are established.

On this basis we can find an explanation for much of the mystery of chemical, electrical, and medical sciences. For example, acids and alkalis are antagonistic (the two extremes of Aristotle); acids have a violent desire to acquire electrons, alkalis have electrons to give away should the environment be suitable. The former is obviously the deficiency and the latter the excess, and stability is only reached by a convenient blending of the two basic and reciprocal desires.

In the case of a simple acid solution the hydrogen atoms have had their electrons taken away by the powerful non-metal radicals, and therefore it has a strong urge to regain its neutrality. Acids are usually tested by estimating the hydrogen-

ion concentration of the solution, ionised hydrogen being in reality the hydrogen nucleus without its electron. From these remarks it should be easy to visualise an acid state as one in which there is a deficiency of electrons.

An alkali, on the other hand, has more than satisfied its needs and has electrons available to give away. In a basic salt or neutral state both charges are equally satisfied, and the resulting solution is consequently comparatively inert. The forces of attraction or repulsion of atoms for electrons vary according to the charges carried by their respective nuclei and vary somewhat in different elements. Therein, it seems, lies the whole difficulty of modern chemio-therapy.

The tests of modern biology are not yet devised in such a manner as to indicate accurately the energy content or electronic state of the blood. Without an accurate test it is manifestly impossible to attain that perfection of diagnosis and treatment which will come as more work is done along these lines. At the same time, as will become evident later, there are a number of tests which can give very helpful information in this direction. In other words, although the perfect test is not yet discovered, present knowledge can be applied with enormous benefit to suffering humanity.

The blood, being a very complicated chemical system, is in a constant state of chemical and electrical change, and examination presents many difficulties. The pH value can only vary within very small limits, or death results. All the time, however, food is being assimilated, transmuted into energy, and by-products are being eliminated. If we view this process side by side with the conception of electron interchange, we can see a number of facts of enormous interest and vast possibilities. It must be remembered that the pH value, depending as it does on the H-ion content of a solution, only indicates fully ionised atoms — in the blood there may be countless numbers of atoms and molecules "partially ionised." In other words, their energy is

only partly converted. Whereas this state may be insufficient to change the pH, it probably has great influence on physiological function, owing to the fact that the cells are obtaining their energy from sources which may not be able to completely satisfy their needs.

Now we come to the most important point of all. Health depends on a freely available interchange of atomic energy in the body. My present conception of disease is therefore based on the study of a deficiency and an excess of electrionic energy in the blood serum. In the case of deficiency we have a tendency to acidosis; this will tend to reduce or rob electrons or energy from atoms or molecules in the vicinity according to the mutual potency as suggested by the electro-motive series. The result in the body will be that the complex substances, robbed of vital constituents necessary for their normal existence, will tend to disintegrate and go into solution.

In the opposing case, that of an excess, there will naturally be a tendency for the opposite condition to prevail. Electrons will be too freely available, and substances which should normally be in a state of balance will tend to retain unnecessary energy. This will condense the constituents, which will therefore tend to become solid and precipitate.

It should now be possible to see the connection between the several parts. In the former case we see McDonagh's dehydration and Broderick's acidosis. In the latter their hydration and alkalosis respectively. The causative or curative factor cannot obviously be dealt with yet. First of all it will be necessary to consider many other points upon which these ideas are based.

In concluding this chapter it will be well to indicate a clear picture more or less analogous to these opposing states. Imagine, therefore, a large enclosure with a number of carnivorous animals penned within. If all their bellies were satisfied there should be a state of the maximum activity with

the minimum of antagonism, a state of comparative quiet or balance. Should the animals be deprived of food (electrons) we might get an atmosphere of wildness, where all the animals would become frenzied with hunger

and eventually would tear each other and possibly the enclosure to pieces — our deficiency or acidosis. On the other hand, if the animals were overfed, there would come about a state of bulging bellies and somnolence, and the supplying of further food would probably not be noticed. So, too, in the blood plasma we have a somewhat similar state in that the energy quanta comprises the food and the atoms the beasts. The electromotive series is some indication of the degree of hunger.

The words acid and alkali have an accepted meaning in modern chemistry — but we now see that an expansion of the meaning of these two words to include this deficiency or excess of electrons would enable their use to cover states which at present have no simple nomenclature to describe them. In the following pages, if these words are used in the sense suggested, the reader must interpret them in a slightly broader meaning than is used in orthodox chemistry. In other words, an acidosis may mean a shortage of electrons or a loosening of atomic energy, and an alkalosis suggests an excess of electrons or a binding-up of atomic energy.

To every action there is, according to the laws of mechanics, an equal and opposite reaction. We have seen in chemical reaction how the electron changes its position under certain circumstances. The atom as a whole can contract or expand. Under a certain degree of stimulation an electron can even jump away from an atom. So much can be taken as an established fact of modern chemistry.

This occurrence is a common physical happening in everyday life. An element, say a bar of iron, is heated; the atoms are energised and expand. Energy is given to the atom so that it becomes greater in size and eventually some electrons will fly

off. The excited atom readily combines with oxygen to form the oxide or rust. It should not therefore be difficult to understand the opposite phenomena, to wit, the tightening-up or contraction of the atom. At the same time it is much more difficult to follow this in an experimental manner. Theoretically the practical findings of isotopes might be constructed to suggest that energy may become bound up eventually in the nucleus. The electron is brought into such intimate contact with the proton that the two become a neutron or bound unit in the nucleus. A similar change takes place in the manufacture of artificial radio-active elements, but the change is sudden.

Life demands a free and well-controlled interchange of energy — electrons must be easily movable in their orbits. The colloidal particles, we will see later, act as accumulators for energy. In the blood serum some of the particles may liberate too much energy and break up, or on the other hand they may bind the energy too closely and tend to condense toward the nucleus.

If the electron is taken from an atom by an external attraction, the attraction on the other electrons of the same atom may be loosened. If the electron is shot off by some means similar to radio-activity, there may be a kick back on the residual electrons which tends to bind up some energy and make it more difficult to free.

The exact details of this energy interchange are but imperfectly understood. In the following chapters an attempt is made to expand this idea further, into the realms of somewhat larger particles, and to show how this may have a bearing on the behaviour of colloidal particles. Through these energy is organised in such a manner as to render life possible. It is also shown how an upset of this interchange renders possible the occurrence of disease and death.

Chapter VI

COLLOIDAL COMPLEXITY

The word 'colloid' is derived from the Greek phrase meaning 'like glue.' This gelatinous substance illustrates many of properties typical of this class of compounds. Colloids and their properties, although not recognised as such, have been known since ancient times. In fact, the early Egyptians used the adsorptive properties of these substances in quarrying. A piece of dry stick was forced into a fissure in the rock. On wetting, the dry cellular matter swelled, causing the aperture to widen and so break the rock.

Probably the first scientific work on colloidal properties was done in 1861 by Thomas Graham, who was then Master of the Mint. In a paper read to the Royal Society, entitled "Liquid Diffusion applied to Analysis," he describes the Basis of Colloidality as probably being the grouping together of a number of cryatalloid molecules held together by forces of electrionic attraction. This view is fairly generally held today; and it can be seen from what has transpired in the previous chapters that, with such a grouping together of atoms, the interchange of atomic energy takes on a modified form to that simple exchange which take place between atoms and electrons. In a solution of crystalloids there is a state of molecular subdivision; that is, they are subdivided into atoms and small molecules which are frequently ionised. The colloidal state is a lesser degree of subdivision, and the particles are consequently more cumbersome. The particles are too large to be ionised, but they can have very great capacity for interchange of electrionic energy in their molecular arrangement.

The size of colloidal molecules is taken to be approximately between 5μ and $50\mu\mu$; a micron (μ) being 1/1000th part of a millimetre. This cannot be taken as a hard-and fast rule, because the size of the, particle is not the only consideration in the regulation of the properties of the colloidal substance. When it is realised that a great number of organic chemicals connected with the phenomena of life behave as colloids, the relative importance of this branch of science should be appreciated. Most modern books on physiology mention these substances but do not deal adequately with their application to practical routine.

The definition of a colloid is it matter of some difficulty owing to the divergent behaviour of substances which constitute this class. Baker (1932) defines the word "colloid (from the Greek kolla) = like glue; applied chemically to uncrystallisable liquids or semi-solids; to amorphous minerals; pathologically applied to the degeneration of albuminous substance of cells into jelly-like matter; capable only of very slow diffusion or penetration." All of which seems very indefinite; but that, as it happens, is exactly what a colloid is. Colloidal differ from crystalline substances in that they have no precise molecular arrangement, consequently the arrangement is subject to an alteration which is dependent on slight modifications in their environment. Crystals are rigid in structure with a precise and definite arrangement of components. Colloids are plastic and porous, which enables diffusion to take place within and through the molecule. Crystalloid state is static, whereas colloidal state is dynamic.

The best way then to define a colloid is probably by an enumeration of its properties. At the same time it must be remembered that all these properties need not be possessed by any particular colloid at any particular time.

Properties of Colloids

- I. Molecular size between 5μ and $50\mu\mu$.
2. Viscosity.

3. Electrical charge and migration.
4. Pectisation (coagulation) and peptisation (liquefaction).
5. Dialysis, diffusion, and ultrafiltration.
6. Protection.
7. Reversibility.
8. Peculiar optical behaviour of hydrosols.
9. Delayed reaction.
10. Imbibition.

Before enlarging on the properties of colloids individually it would be well for the reader to have a practical conception of colloidal types of substances in his mind. Below is appended a classification of the various types of mixtures which can take the form of colloidal suspensions. There are three well-known states in which matter can exist, i.e. gas, liquid, and solid. Consequently suspensions of any two of the states, one in the other, can have nine possible examples. It may be seen from the table that examples can be found for all states with the exception of the first, gas in gas, which in all cases must result in a perfect mixture owing to the small size of the gas molecule under normal conditions.

Mixture Varieties of Colloidal Solutions

Dispersed Phase	Dispersion Medium	Example
Gas	Gas	None.
Gas	Liquid	Foam, gas in beer.
Gas	Solid	Oxygen in gold, pumice.
Liquid	Gas	Fog, clouds.
Liquid	Liquid	Oil in water, emulsions, milk.
Liquid	Solid	Hg ointment.
Solid	Gas	Smoke, ammonium chloride vapour.
Solid	Liquid	Colloidal metals.
Solid	Solid	Gold in ruby glass, colour in gems.

Having noted these examples the reader will now be able to follow more easily the detailed description of colloidal properties.

1. **Molecular size** lies between 5μ and $50\mu\mu$. This is an arbitrary limitation, and it is usually between these limits that molecules with colloidal properties exist. Starling (1930) gives the molecular size of water (H_2O) as 0.7×10^{-8} or $0.7 \times 1\mu\mu$. A molecule 10,000 times that size would be $0.7 \times 10^{-4}mm.$, which would be well within the limits of ultra-microscopic visibility. Colloids have very large and complex molecules by comparison with atoms. Hæmoglobin has a molecular weight of at least 16,000 and protein, Mee (1934) suggests, about 34,500. Cell proteins built up of various compounds are probably in the region 100,000. Long before molecules reached this size they would be past the limits of atoms and radicles capable of chemical ionisation or action, or even past the size where they could behave as molecules in chemical reaction. Therefore large aggregations of atoms in colloid molecules would act more by adsorption at the surface than by interaction of molecules.

2. **Viscosity** is defined by Baker (1932) as "stickiness, thickness of fluid; the property of fluids, semi-fluids, and gases by which they resist changes of shape, or arrangement of molecules; internal friction." Viscosity is measured by flow in a capillary tube, or through a measured orifice under definite pressure. It depends on the ease of movement of the suspended particles. Owing to the large size of the colloid molecule and its behaviour by adsorption or attraction at its surface there is a large attractive action between the molecules in certain suspensions. It is to this peculiarity that and various other adhesives owe their useful properties.

3. **Electrical charge and migration.** — Particles in suspension carry an electrical charge, and will therefore tend to move towards the pole of the opposite sign when an electric current is passed. Cohen's Law states that "when two substances

are in contact the one with the higher di-electric constant is positively charged." Water has a high constant of 80. For that reason most substances suspended in water would bear a negative charge. Oil of turpentine has a low constant of 2.23. Consequently particles suspended therein would bear a positive charge. The presence of electrolytes modifies this rule very considerably, and this fact has a very important bearing on the application of colloid chemistry to the study of blood serum, as will be shown in later chapters. Traces of an alkali tend to give a negative charge. Traces of an acid will tend to give, on the other hand, a positive charge to the suspended particle. This is most probably due to the adsorption of ions at the surface of the suspended particle.

Electrically charged particles tend to surround themselves with ions of the opposite charge. Also polar molecules may be oriented at the interfaces. This characteristic may be so pronounced as to form an almost skin-like covering to the particle, which then is termed a micellæ. As a matter of speculation the analogy between the cell in the body, as well as bacteria, and the structure of the micellæ forms an interesting thought. This suggestion may help the reader to grade some of the basic phenomena of life along the lines already suggested in a previous chapter, notably the scale of condensation from atoms to animals.

-Negative	+Positive
1. Hydrates of Fe, Cu, Al, Zn 2. Colloidal Bi, Pb, Fe, Au.	1. Sulphides of As, Cu, Pb. 2. Coloidal Pt, Cu, Ag, Hg, I, S
3. Albumin, hæmoglobin, agar	3. Gum arabic, soluble starch, gamboge, mastic, oil emulsion.
4. Basic dyes; methyl violet Bismarck brown, Hoffmann violet.	4. Acid dyes; eosin, fuchsin, aniline blue, indigo, Prussian blue.

There are other factors which govern the charge carried by the particle. On p. 89 is appended a list of certain substances classified according to the charge they tend to take. It must be remembered, however, that this charge is relative, and it depends on the mode of preparation and conditions prevailing previous and at the time of examination.

4. **Pectisation and peptisation** mean, respectively, coagulation and liquefaction. Alexander (1928) says that coagulation depends on the addition of an ion bearing an opposite charge to that of the colloidal particle. In considering the effect of salts, trivalent ions have greater power of coagulation than divalent ions, which again exert a more pronounced effect than monovalent. This has considerable bearing on the treatment of bleeding in the human body. Acids and alkalis act more strongly than the corresponding salts. Electrical discharges pressure, and temperature also have an effect. Pectisation can be illustrated by the coagulation or souring of previously alkaline milk owing to the formation of lactic acid, which souring may be prevented by the addition of a small quantity of bicarbonate of soda to neutralise the effect of the acid ion. Peptisation can be illustrated by the effect and sequence of digestion of food in the stomach, or the detergent action of soaps on dirt.

Coagulation can be explained by the fact that hydrosols are unstable, and the relationship between particle and medium may be disturbed by slight changes of reaction or the addition of salts. This change may cause particles to aggregate, and consequently the internal friction becomes greater, eventually forming a gel. For example, gelatine is a hydrosol when warm and a hydrogel when cold. Agar behaves similarly. If calcium chloride is added to an alkaline solution of casein the resultant mixture gives a jelly when warm and a liquid when cool. Colloidal silica gives a solid gel with traces of a neutral salt which is irreversible; that is, it cannot be returned easily to

liquid form.

The inertia of the colloidal system gives a false equilibrium. Once configuration is established a slight overreaching of the conditions of formation will tend to destroy the system. A 10 per cent. solution of gelatine sets on cooling at 21°C., but it does not melt again till the heat reaches 29.6°C. A solution of agar sets at 35°C. and melts at 90°C. Albumin and globulin are coagulated by heat, but in dilute solutions they will only flocculate out as precipitates. Mechanical peptisation can be brought about by shaking or stirring — defibrinated blood. The apparent reason is that the agitation of the spatula forms a pellicle of molecules which continues to deposit as long as agitation is maintained, or till the solution is exhausted.

5. **Dialysis, diffusion, and ultrafiltration** are properties of matter which enable small molecules to be separated from larger ones by their varying abilities to pass through membranes or similar structures. In dialysis, a membrane is stretched across one end of a tube, which is then filled with water and the membrane covered and immersed in the hydrosol. The smaller atoms and molecules are able to diffuse through in an effort to equalise the osmotic pressure on both sides, with the result that the colloid is separated from the smaller molecules. Ultrafiltration is a similar process and is used in bacteriological research for the concentration of ultra-microscopic viruses and the like. Absorption of food in the intestine is governed by these phenomena.

6. **Protection** was first suggested by Jacobi (1889) when he advised the addition of gelatin and gum arabic to modify milk for feeding infants. Zsigmondy (1909), however, was probably the first man to realise the full value of protection. The addition of gum, gelatin, or the like tend to stabilise the colloidal solution if the presence of a coagulating agent be avoided. A less stable colloid is protected by a more stable colloid.

Protection is most likely controlled by the nature of the outer

layer of particles. Chemical action depends on the nuclear charge or elemental structure composing the inner part of the particle. Cumulative protection is present in the blood plasma and serum.

The rule for protectors is that anything which removes coagulates or destroys the protector or causes it to crystallise will make the dispersed phase coagulate. For example, ferric chloride if added to olive oil emulsified with gum arabic will break the emulsion and cause separation. Likewise anything which protects the protector will tend to stabilise the solution. Ammonia in a gelatin-protected solution prevents its coagulation by formaldehyde. anti-septics sometimes prevent dispersion of certain sols by bacteria or enzymes. In brewing, albumin and dextrin must be clear in the final product. Traces of acid, together with tannin and resin from the hops, tend to stabilise the albumin as also do the inorganic salts of calcium and magnesium. The River Trent contains these salts in correct proportions, and this is why certain ales brewed in that area are noted for their quality.

Citrates, sulphocyanates, and other salts of similar nature tend to stabilise, as also do most reversible colloids. If a reversible colloid be added to an irreversible colloid the latter acquires the properties of the former.

7. **Reversible colloids** have properties which can briefly be stated as follows: insensitivity to electrolytes; power of redissolving after desiccation (if the temperature used is not too high to render the protector insoluble); and passage through ultra filters which would otherwise hold back. These characteristics are probably due to a softness or plasticity of the molecular arrangement. In certain circumstances it is possible to actually see the blood corpuscles bend into shapes which illustrate this plasticity diagrammatically.

Probably the protector changes the total charge of the molecule and so alters the behaviour. When very small

quantities are used they may sensitise and even flocculate. Beehold (1920) describes experiments which show that 0.0003 to 0.0001 parts per million of gelatin flocculate gold sols or oil emulsion. It is quite likely that this property of protection may suggest a certain amount of truth and reason in the methods of homeopathic medicine, as their methods prescribe small and in some cases incredibly small doses.

8. **The peculiar optical behaviour of hydrosols** is shown by most particles in suspension, which have a size from 5μ to 50μ . This is known as the Faraday-Tyndall phenomenon. As the headlights of a car illuminate the particles of moisture in the air on foggy night, so a very similar effect is noticed in hydrosols on projecting a strong beam of light into them. Gold glass gives a very pretty fluorescent yellow colour. If the particles are sufficiently small, i.e. those at the lower end of the limits given above, the rays reflected at right angles are polarised. Particles less than one-half the wave-length of light (about $.2\mu$) cannot be seen with the microscope, and these are visible only when they behave as centres for dispersing of light and consequently appear as small circular spheres. More will be told about these limits in the chapter dealing with the ultra-microscopic examination of hydrosols.

9. **A delayed reaction** of colloidal suspensions is probably due to the large size of the molecule, owing to which the addition or subtraction of an atom or electron causes a gradual sorting-out or rearrangement of the other constituents of the particle. Time is often a very necessary factor to consider in changes of the colloidal state. Owing, therefore, to the large complicated structure, colloidal activity lacks the preciseness of chemical reaction. This fact is the one which makes the treatment of disease a matter of some difficulty. The blood and body cells are largely composed of colloidal arrangements and therefore medication can rarely be precise.

10. **Imbibition or adsorption of water** is another

characteristic dependant on the complex molecule. Owing to its atomic structure it appears to be somewhat porous to smaller molecules. If these are of the correct electric capacity they can therefore be adsorbed intimately into the structure of the particle.

The foregoing theoretical considerations can be better understood by examining some of the more practical applications of this subject. Colloids are comparatively fixed or slow in diffusion. This state is marked by an absence of power to crystallise. For example, take silicic acid, alumina, or the metal peroxides of the aluminous class in soluble form. The hydrates of these substances are gelatinous in character. Though often soluble in water they are held in solution by a very feeble force. They are practically inert in the capacity of acids and bases, which fact explains why purely chemical tests do not apply accurately to body reactions in all cases. Along the same lines can be explained why the pH values of the blood do not show a greater degree of change in organic disease. The pH only gives an indication of the presence of completely ionised hydrogen, and in colloidal sols there is no real ionisation, as the loss of an electron or two merely causes a rearrangement of the remaining constituents; and so does not give the full effect of ionisation as required for pH tests with indicators.

The physical forms or states of subdivision in which colloidal states of matter exist possess activity, but with chemical indifference — this fact seems to be a property essential for the organic process of life. To visualise in some manner what is happening in a colloidal molecule it will now be necessary to consider atoms and electrons, to picture the particle as an aggregation of varying parts, to approach it from below and above in point of size. The number of molecules in one cubic centimetre of air has been calculated by Fisk (1936) to be of the order of twenty-seven trillions, in figures that is 270,000,000,000,000. In the highest vacuum which can be

produced by man the quantity of molecules is a number with several noughts in it.

Professor Milliken, quoted by Alexander (1928), suggests that if the population of Chicago numbering two and a half millions (2,500,000) were set to work counting the number of electrons passing as an electric current in an ordinary household incandescent lamp filament for a small period of one second, counting at the rate of two per second, day and night, it would take them about 20,000 years to complete their task.

In dealing with colloidal substances, therefore, we are dealing with comparatively large aggregations of atoms. Possibly molecules of the size under consideration have several thousand atoms, maybe more or less.

There are four forces of attraction known to science and these were classified by Wells (1919) under the following heads:

- | | |
|---------------|---|
| 1. Electronic | Positive nucleus, and negative electrons in equilibrium as single system. |
| 2. Atomic | Two or more atoms in equilibrium. |
| 3. Molecular | Two or more molecules. |
| 4. Molar | Two or more masses. |

Molecular forces are responsible for physico-chemical and colloidal phenomena. Molar forces control physical and astronomical phenomena. Molecular groups or aggregations are not small enough for precise chemical activity. Owing to the electronic arrangement and grouping of the molecules, which gives them an almost cellular structure, they have an enormous power for adsorption. This is governed to a very large extent by their ionic concentration (electron arrangement) and quality of dispersal medium.

Interfacial anomalies are important. It has been stated above that the molecules at the surface probably occupy different positions from those in the centre of mass. This forms a surface skin to the micellæ, which will vary as the relative attractions

vary. In other words, asymmetrical molecules will be oriented so that the end carrying the greater negative charge will turn to the attractive force carrying the opposite sign. Something of this nature can be demonstrated by cleaving a piece of mica and putting the new surfaces together. If this is done immediately they will adhere, which power is lost if approximation is delayed, owing, to adsorption of particles from the atmosphere. In a like manner cast-iron broken under mercury amalgamates. But if broken in air and immersed immediately it does not, so quickly does adsorption take place.

It is an interfacial attraction of this type which gives colloids the power to adsorb certain substances. This power depends on the arrangement of the molecules. Symmetrical short chain saturated paraffins do not show as much evidence of orientation as do the heavier molecules. Most of these substances are electrically inactive, being non-conductors.

Attraction also depends on the ratio of mass of particle to the surface area. This in turn will vary according to shape. For all practical purposes it can be assumed that the shape is more or less spherical. The area of a sphere increases as the square of its radius, but its bulk increases as the cube. Large particles will have their ratio of surface to mass approaching infinity. With the very small particles the ratio will, on the other hand, tend to approach zero. In other words, a very large sphere has relatively small surface, whereas a very tiny one has a comparatively large surface. At one point between these two extremes this ratio of physical surface to chemical mass will obviously be at the optimum point for the maximum potential interchange of energy. This phase may be reached in two ways, aggregation and dispersion. Aggregation is going up and dispersion down the scale of size.

A glance at the accompanying table (Fig. 12) will give an idea of the enormous number of particles in a colloidal subdivision of matter. Suppose a cube of 1 cm. side is

	Edge in Metres	Length	Number of cubes	Surface Area
	10^{-2}	1 cm	1	6 sq. cm.
	10^{-3}	1 mm	1,000	60 "
Infra-red	10^{-4}	.1 mm	1,000	600 "
↑	10^{-5}	.01 mm	1,000,000	6,000 "
Visible spectrum	10^{-6}	1 μ	1,000,000,000	6 sq. m.
↑	10^{-7}	.1 μ	1,000,000,000,000	60 "
Ultra violet	10^{-8}	.01 μ	1,000,000,000,000,000	600 "
↑	10^{-9}	1 $\mu\mu$	1,000,000,000,000,000,000	6,000 "
X-ray	10^{-10}	.1 $\mu\mu$	1,000,000,000,000,000,000,000	60,000 "
↓	10^{-11}	.01 $\mu\mu$	1,000,000,000,000,000,000,000,000	
Small molecules →	10^{-12}		1,000,000,000,000,000,000,000,000,000	
and atoms →				

(1 μ = one thousandth of a mm.)

Fig 12. — Progressive Subdivisions of a Cube.

progressively subdivided, the table shows the effect at a glance. Like the school tale of the horseshoe, the nail, and the battle, the increase is spectacular. For comparison, and for the reader's guidance, the approximate limits of light-rays are inserted on the left of the scale. It can be easily seen that colloidal state lie therefore about the region of and below the limits, of size of ordinary visible light rays — which will indicate one of the great difficulties in research along these lines.

Colloids have a comparatively wide range of size, indefinite properties, and somewhat uncertain reactions, which reasons explain why workers have not until recently been able to approach colloidal chemistry in a scientific manner. Owing to the fact that a colloid such as glue can change its properties alternately from a solid to a liquid has caused many workers to attempt to classify and define these substances along these lines. The more common titles are given below, with the name of their various authors:

Hydrophobe and Hydrophile . . .	Freudlich.
Lytrophobe and Lytrophile	Perrin.
Suspensoid and Emulsoid	Ostwald.
Irreversible and Reversible	Zsigmondy.

These names are easily understood from the Greek

Hydro	=	water.
Lyto	=	solid.
Phobe	=	hating.
Phile	=	loving.

One phase may become another, that is, an emulsoid may become suspensoid, milk fat may become butter. Milk is really a suspensoid of solid fats in a watery medium, whereas butter is a suspension of liquid water in the solid fats.

Sometimes they are completely irreversible and may coagulate while dilute, and separate as a precipitate from the

solvent, forming no gel — for example, many colloidal metals behave in this manner. In these cases, chemical energy has to be supplied to reverse the phase. The incompletely reversible colloids form a gel, which is easily returned by small quantities of reagents.

Protective colloids are usually similar to glue in certain respects. They have a strong inter-molecular attraction as well as a strong attraction for other molecules. They are more sturdy in make-up. It is from this characteristic that glue and other adhesives probably derive their usefulness.

In order to impress the importance of colloidal chemistry on the reader, it should only be necessary to remind him that the large majority of substances which maintain and are the result of living processes are in that peculiar kind of subdivision and molecular size known as the colloidal state. In all probability bacteria and single cells are the border-line of increasing size where life may be assumed to begin. The scale of the electromagnetic waves, from the long wireless waves to the ultra-short gamma rays of radium, are known known to form a graded scale of size. In an earlier chapter there has been indicated the possibilities of a different scale of size which is not yet popularly regarded as such. In the condensation or grouping of electrons and protons we have the varying atoms; by combining atoms there results molecules, first simple and then complex; by combining molecules in certain arrangements we arrive at colloids, with their very complicated structures. A little further are bacteria and single cells; further still, simple collections of cells in lower animal and plant life, and so on to large animals and human beings; to the family, the race, and the world.

As the colloidal state is situated in this scale a little below the bacteria and monocells, it seems that somewhere in this almost unexplored region might be found the key which would unlock the door to the secret of where life begins. For the deep thinker the study of colloids is pregnant with possibilities, and yet it is

all too little appreciated, almost ignored in fact by many.

To indicate, therefore, the great importance of these thoughts this chapter concludes with a brief résumé of some of the practical applications of colloidal chemistry in everyday life.

Cooking. —From time immemorial a large number of cooking principles have been known and used. These are largely a matter of colloidal chemistry — tomato soup, mayonnaise, butter-making, and brewing, to mention just a few.

The Universe presents a varying panorama of colloidal phenomena. Changing weather conditions such as the evening mist appearing in the quiet air after sundown is merely a change in the particle size rendering the water visible. The condensation causes an accumulation of electric current, and when the potential becomes too high lightning flashes to an adjacent area of lower potential to equalise matters. The colours of the sky on a clear day are due to the Faraday-Tyndall effect on particles. Otherwise stars would be visible in daylight. Recently this fact has been vouched for by the altitude-record pilots who described this peculiar phenomenon amongst others after their experiences at great heights.

Soaps are colloids, which explains some of the difficulties met in soap manufacture. Unless made in large quantities and under rigid conditions no two batches of soap will be exactly alike. The detergent action of soap is due to the action of the negatively charged particles of soap going into solution, attracting and loosening the positively charged particles of dirt from their seats. A drop of used bath water under the ultra-microscope exhibits characteristics very similar in some respects to a slide of blood serum. The particles of soap exhibit the typical Brownian movement of serum colloids. Transparent soaps are manufactured by keeping the particles to the lower limits of size by the following principles:—

1. Careful selection of the fatty acid.
2. Quick chilling.
3. Protective colloids.
4. Addition of alcohol, glycene, sugar, or other substances which tend to make the particles smaller and dissolve the soap crystalloidally.

Fire foam extinguishers consist largely of CO₂ froth. They are usually prepared from a mixture of bicarbonate of soda and alum. Protective colloids such as liquorice, glue, dextrin, or saponin may be added to stabilise and prevent the bubbles from easy dissipation.

Most **Disinfectants** in solution also show a typical Brownian movement under the ultra-microscope. Colloidal dilution is an economical way of applying strong insecticides. A concentrated solution is wasteful and often would be harmful or dangerous to use. The leaves of the growing plant are negatively charged, consequently a positively charged colloid will tend to cling.

Bread is a colloidal mixture of starch, gluten, salt, yeast, fat, and milk. The gluten acts as a protector to the starch, the salt enables the gluten to adsorb and hold the water, which effect is, incidentally, peculiar to chlorides. A hard water containing sulphates tends to harden the gluten. Alkaline waters tend to disintegrate and destroy elasticity. Distilled water results in a sticky dough. The fats coat the particles and tend to prevent desiccation.

Milk is partly colloid and partly emulsoid. Coagulation by dilute acids can be watched under the ultra-microscope. The stabilisation by sodium bicarbonate has already been mentioned.

Pharmacy has many uses for colloids. Mercury ointment has been known and used for many years. Emulsions of oil are made with gum acacia or arabic, egg-yolk, Irish moss, or tragacanth. Milk of magnesia is kept in the colloidal state with protectors.

Therapeutics also give many examples. A few only need be

mentioned here as many more will be introduced in later chapters. Gelatine in normal saline, is all intravenous injection for bleeders, is effective in increasing blood-pressure and viscosity; citrates, oxalates, and hirudin (leech extract) tend to retard or stop coagulation.

Enzymes probably act as catalysts. They have a large, easily available electrical charge and can easily bring about an alteration in arrangement of the colloid molecule grouping. All are colloids and depend for their function on the protectors adsorbed to the molecule. Pure enzymes are very unstable, and that is why great difficulty has been experienced in preparing them in this state. The effective pH of the solution also influences the enzyme action.

Before dealing with practical body colloids it will be necessary to illustrate the preparation of these substances with one or two examples in order to give the reader a better idea of colloidal behaviour.

Starling (1930) describes the preparation of colloidal silicic acid as follows: First neutralise a weak solution of sodium silicate with hydrochloric acid. Dialyse for several days against distilled water. Sodium chloride passes out through the membrane leaving behind solution of silicic acid. Concentrate this over sulphuric acid. When reduced to a syrupy consistency the resultant substance is unstable. Addition of electrolytes in minute traces will cause a gel with a rise in temperature. Coagulation by dissipating bound-up energy in the form of heat gives an interesting analogy to certain disease conditions. The change above described is irreversible, but if allowed to stand in a weak alkali for a long time the coagulum eventually passes into solution.

Faraday prepared colloidal gold by treating a solution of gold chloride with phosphorus. His preparation kept for months and could be filtered without precipitation. The gold, however, could be thrown down by minute quantities of impurities. The

addition of a small amount of jelly gave the solution greater stability and permanence.

Bredig as early as 1899 made hydrosols by arcing metal electrodes under distilled water.

Some properties of gels are not commonly known. When gelatine sets, the process may be watched the ultra-microscope. The particles appear to enlarge and touch each other, eventually forming a network, the dispersed phase becoming the dispersion phase. Some compounds lose water, some gain it, and some remain unchanged. The particle behaves rather like the ion of an electrolyte, but it has no quantitative value as in chemical reactions. The factors involved are:

1. Extent of surface.
2. Chemical nature of particle.
3. Electrical charge on surface (which also depends on suspension medium).

The continuous washing of colloids will not wash away all the electrolytes. Their removal becomes progressively slower and slower.

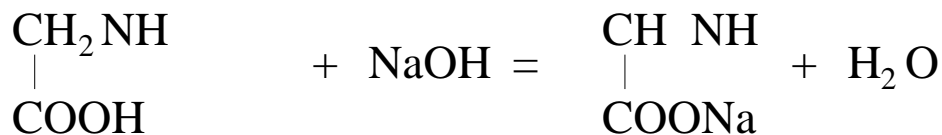
The adsorption ability of colloids is aptly illustrated by globulin, which has four possible states:

1. With acid.
3. With alkali.
4. With neutral salts.

HCl-globulin when dried contains all the chlorine, which was used to dissolve it, in chemical combination. Acids and alkali act as electrolytes and also tend to convert the opaque thick substances into a clear solution. Double the amount of alkali to acid is required in order to bring about this effect.

Ampholytes or amphoteric substances are those similar in character to the amino acids which react as acids with bases, or as bases with acids. They do this solely on account of their ability to orient their molecular groupings according to environment. For example:

Glycine



Globulin forms soluble compounds with neutral salts.

The particles are sometimes referred to as pseudo-ions owing to their ability to carry either a positive or negative charge. At a certain H-ion concentration they carry no charge and this is called the iso-electrical point. At this particular point the sol shows the maximum precipitation, minimum viscosity, and minimum imbibition.

Adsorbed combinations cause the colloid to show an absence of definite equilibrium. The inertia of the system and large size of molecule together with its orientation determine the occurrence of delayed reaction. This is to a great extent also determined by the previous history of the system. This fact has an interesting bearing on the administration of drugs, and may suggest why with continued use a specific drug may lose or even change its action in human medication.

In the combinations between colloids it is found that some precipitate others, some protect others. Precipitation is brought about by combination of colloids bearing the opposite charge. Colloids of the blood serum can dissolve an amount of globulin, and the resulting solution shows no drift when its cataphoresis is studied. The protective colloid in this case carries no charge. A similar effect is obtained if a large excess of negative colloid is added to a positive one. The interaction is probably on common lines with the action of toxin and antitoxin, enzyme and substrate. Adsorption compounds are formed which have a balanced or neutral charge.

Perhaps at this stage of our researches the reader will not be

too startled if he is given a quick résumé of the above material. From Aristotle's Doctrine of the Mean similar balance has been traced through the intricate paths of historic alchemy and modern electron physics to colloidal chemistry, which is the foundation of life itself.

So now, perhaps, the reader can look back and see the fullness of life as a balance between an excess and a deficiency of electronic energy in the blood-stream. The colloids, owing to their indefinite action, can maintain their useful function with varying charges of energy (positive and negative). If the change proceeds too far in either direction the colloidal system is disturbed, with the result that disease appears. Be that as it may, the possibility of having large changes of potential energy or relative charge without apparently affecting the reaction of the suspension medium may help the reader to see the reason why the pH of the blood-stream never varies greatly. Therefore he may understand why the acid (electron shortage) and alkaline (electron excess) states have been incapable of easy demonstration in such a complicated system as the blood serum by ordinary chemical methods. With these ideas in mind our researches can now be directed into a more interesting channel and applied to the study of health and disease in the human body.

PART II

**ELECTRONIC ACTIVITY AS AN AID
TO DIAGNOSIS.**

CHAPTER VII

DENTAL MEDICINE

DENTAL Surgery is at present a purely palliative treatment. As dental surgeons we can patch a cavity with amalgam or silicate, but by these methods we cannot cure the caries. In spite of theories about decay and pyorrhœa very little definite result of a practical nature has been achieved to date. That is where Dental Medicine, or more accurately Electrionic Medicine, should come in and become a most powerful weapon in the armamentarium of Preventive Dentistry. An old axiom states that the part cannot be greater than the whole. Why then have dental researches been confined nearly always to the part and not to the whole? In this chapter my intentions are therefore to direct your attention to the body as a whole, to review the atomic structure of matter, to indicate how that basis affects life in health and disease, and to lay down one or two suggestions which will enable the reader to get the general outline of the story before elaborating it in detail. In order to simplify the conception of intricate detail it is necessary to make concise statements which may appear too sweeping. The subject with which we are about to deal has taken a considerable amount of concentrated study and experimental research, and no one can hope to fully master the matter without reading widely and experimenting personally. The following outline may, however, convince the reader that here we have at last real truth and an explanation for much that has hitherto puzzled both the dental and medical professions. It is hoped that it will interest you sufficiently, so that you will be curious to try, and prove for yourselves the practical

application of so great a subject. Should, therefore, my statements appear dogmatic, I would ask you to blame my enthusiasm and not to condemn the principles involved.

You are all doubtless familiar with the work of Broderick (1936), in which he states caries and pyorrhœa are two antagonistic conditions dependent respectively on the ratio of

Sympathetic to Parasympathetic,
Calcium to Potassium,
Acid to Alkali,

and other factors. Progressing further along the lines of McDonagh (1926-1936), disease is traced to upsets in the colloidal chemistry of the blood serum.

Having studied the works of these two men extensively, there seemed much in their teachings which was impossible for the ordinary dental practitioner to understand. Being naturally of a somewhat curious disposition I have sought the answers in allied sciences, and now feel that dental medicine is founded on the bedrock of modern scientific findings. I have taken the matter further back than acids and alkalis, or colloidal upsets, to the very structure of the atom itself. As you have seen how the atom is composed and grouped together as molecules, colloidal particles, cells, and then into animals themselves, you will realise that here is the keystone to preventive dentistry, and even more, that here lies the key which will eventually turn medicine from a curative science into a preventive one.

Let us, however, start at the beginning. Modern chemico-physics teaches that the atom is no longer the ultimate unit of matter, but that it can be further divided into electrons and protons, the proton forming a centre nucleus and the electron existing in an orbit about it and probably revolving or oscillating at approximately the speed of light; the rest of the atom is composed of space. In fact, rather than being

composed of solid substances, the atom is merely two or more particles or quanta of energy in a similar relationship to each other as the planets are to the sun. Each electron may have its choice of several orbits, and under certain conditions they can be transferred from one orbit to another. If the particle is energised, or, in other words, if energy is communicated to it, the electron is moved into an orbit farther away, and eventually the attraction between it and the nucleus may be lost, so that it flies off at a tangent. This is what happens in wireless tube and in some radio-active disintegration.

The hydrogen atom is the simplest of all, and consists of a central nucleus with one electron. Helium comes next with two electrons, then come the other elements in accordance with their atomic numbers. For example, lithium has one electron revolving in another orbit outside a helium atom. Beryllium, boron, carbon, nitrogen, oxygen, and fluorine each have a further electron in the outer orbit or shell, whereas neon has its outer shell composed of eight electrons. The next series has a further shell of electrons, increasing in number for the various elements, and so on through the system.

As the exact knowledge of the composition of an atom is impossible to our imperfect senses, science says that the electron is or has a charge of negative electricity and the proton is or has a charge of positive electricity. So we are forced to the conclusion that matter is nothing more or less than minute particles or quanta of electricity or energy which appear to us as matter. In chemical reactions there is an interchange of surface electrons. Acids and alkalis we find are antagonistic. The acid has a violent desire to acquire electrons. The hydrogen has had its electron taken from it by the non-metal radicle and urgently required to regain its neutrality. Acids are tested by the hydrogen-ion content of the solution, ionised hydrogen really being the hydrogen nucleus without its electron. Therefore it is easy to see that an acid state is one in

which there is a deficiency of electrons. An alkali, on the other hand, has more than satisfied its needs and has electrons available to give away. In a base or basic salt, which represents the neutral state, both charges are fully satisfied and the solution is comparatively inert. The attraction of electrons varies according to the charges carried on the respective nuclei and differs in different elements. This has already been described in the electromotive series.

Having seen that an electric current is really a stream of electrons being passed along the wire from atom to atom at the speed of light, we find that the electron is potential energy, and by changing its position in relationship to the nucleus, atomic energy can be radiated or transferred into electricity, heat, or mechanical power. A great number of the commodities bought today are purchased for the available energy contained and not for their atomic value, e.g. petrol, gas, etc. Having gone down the scale let us now consider the aggregation of atoms. First we have the nucleus of one proton, then by the addition of further neutrons and protons have the elements in gradually increasing atomic size according to their atomic numbers. Then there are combinations of various atoms forming molecules of simple and complex compounds. First the inorganic, which usually have comparatively simple structure, and then the organic compounds, which sometimes have very complex structural formulæ. Many of the body constituents consist of these complex substances, and for comparison it is interesting to note that some of the smaller elements have relative weights in the units and two or three figures whereas substances such as hæmoglobin and protein have molecular weights respectively approximating 16,000 and 34,5000.

Let us examine atoms and molecules in increasing size. Water, as we have seen, is near the lower molecular limit, 0.7×10^{-8} mm. A molecule of dimension 10,000 times this size would be well within the limits of microscopic vision provided

there is sufficient difference of refractive index combined with efficient resolving power. Long before this size was reached, groups of atoms would be past the usual limits of ordinary chemical reaction, and would behave by adsorption at the surface rather than by simple interaction. It is at this point of increasing condensation of atomic systems that colloids make their appearance.

If we consider a simple solution such as salt in water the solid is broken up into ions of sodium and chlorine and dispersed evenly throughout the liquid. In a colloidal solution the atoms are not completely dissociated and there results an aggregation or condensation of groups here and there, leaving the intervening liquid comparatively pure. Such conditions sometimes result in a cloudy solution such as lysol or bath water.

The colloidal state is taken roughly to be comprised of particles which have a size of 5μ to 50μ . Assuming these particles to be spherical in shape, the area of a sphere increases as the square of its radius, whereas its mass increases as the cube of same. With particles towards the larger limits the ratio of surface area to mass approaches zero; with very small particles, on the other hand, this ratio approaches infinity. It is therefore obvious that at one point this contrast of chemical mass to physical surface area will be at the optimum ratio for the maximum potential interchange of energy. It is round about this point of size that the colloidal constituents of the blood exist in health. As the particles decrease in size there is an obvious tendency to lysis or going into solution; as they increase they tend to precipitate and go out of solution.

Starling (1930) says that "The two fundamental characteristics of protoplasm which distinguish it above all others from unorganised matter are growth and activity. Growth occurs at the expense of surrounding non-living material, while activity is a reaction to changes in the

environment. In the process of growth of a minute spherical mass of protoplasm, its bulk and mass increase as the cube, while the surface increases only as the square of the radius. Thus the proportion of surface to mass diminishes with increased size of the protoplasmic unit, and since activity is a function of the surface, the larger the unit the smaller relatively must be its activity. It follows that there must be a limiting size to the living cell, and it is on this account that hardly any unicellular animal or plant exceeds a fraction of a millimetre in diameter. If an organism is to attain any larger size, this can only be by a multiplication of units, each presenting the same relative amount of surface as a complete unicellular organism, though that surface may be exposed to an internal and not to an external medium. Another factor, limiting the size of the unicellular organism or of the unit of multi-cellular organism, is the necessity for maintaining a certain proportion between the size of the nucleus and that of the cytoplasm composing the body of the cell. Hence, when for any reason it is advantageous that a cell should attain a large size, such a cell is almost always found to contain many nuclei. All the 'giant cells' found in the body of man under normal or pathological conditions are also multi-nuclear.

The two characteristics here mentioned by Starling, growth and activity, can be seen also in the atom and molecule. Theoretically the hydrogen grows to become helium by acquiring another electron. At present the processes governing this growth or transmutation of atoms are but imperfectly understood. All atoms possess activity, in some it is latent and defies man's power to stimulate it. It is not now very difficult to see that there is a gradual condensation of electrons to form in ascending order of size, atoms, molecules, (inorganic and organic), colloidal particles, bacteria and non-nucleated cells, cells, unicellular organisms, and so on through the scale of life and possibly even to the earth itself, and beyond that to the

universe and galaxies of stars far beyond our ken or comprehension.

McDonagh (1926) suggests that the protein particle is built up in a manner similar to our solar system, with the proton nucleus representing our sun and the various other constituents arranged in layers corresponding to the orbits of the earth and other planets around the nucleus in the following order from within outward — fat, amino acids, sugar, uric acid and urea, inorganic salts and electrons.

To fully understand the importance of this structure of the protein particle it will be necessary to realise that energy in the form of chemical compounds and electrons is conveyed from the food, broken down in the intestine, to the various organs in the 'body that require it. The process is similar in certain respects to the conception of the hæmoglobin in the corpuscles carrying oxygen to the tissues from the lungs and returning with the worn-out or degenerated oxygen in the form of CO_2 as carboxy-hæmoglobin.

Let us revert for a moment to chemical reaction. In the Octet Theory the outer shell of electrons can never be more than eight, and there is a great tendency in atomic combination for atoms to donate temporarily or acquire electrons to reach this number in the outer shells. Acids in solution have an unsatisfied positive charge, that is, the want of an electron; alkalis, on the other hand, have an electron to spare. For that reason the effect of a combination is to produce a stable or more balanced compound. Oxidation and reduction is a somewhat similar condition from an electronic view point. Oxidation, as we have seen, is fit increase of the relative weight of that part of the molecule which carries the negative charge. Oxidation, also, is the removal of an electron or the increase of positive charge. Reduction is the attraction of electrons. In all electric and chemical phenomena there seems to be this passing along or movement of electrons. In moving

an electron, energy is acquired or given up by the atom concerned.

Acid solutions are acid, as we have seen, by virtue of the ionised hydrogen contained therein. Comparatively, then, acids are deficient in electronic energy and alkalis have an excess of electrons.

Returning to our colloidal particle or protein. Owing to the large size compared with the atom or molecule it acts more by adsorption than by direct interchange as in chemical reaction. In the same way that a small magnet can magnetise a large bar of iron, so the charge carried by the nucleus can exert an influence on a large number of molecules situated around it. Imagine a molecule of water as an isosceles triangle, the OH-ion would be larger and occupy the basic half of the triangle, the H-ion would occupy the angle at the apex. The hydroxyl-ion would carry a negative charge, and the H-ion a positive charge. Consequently the triangle would be charged positively at the apex and negatively at the base. The water around a particle carrying a positive charge would have its triangles arranged with the bases towards the centre. A negatively charged particle would have them arranged the opposite way. With a large number of particles in suspension this arrangement would have its effect in making the liquid acid or alkaline respectively owing, to the resultant orientation of charges. On the other hand an excess of acid or alkali, working from the liquid, would alter the relative charge carried by the particle itself. These particles can actually be seen with the aid of the cardioid ultra-microscope, which is described fully in a later chapter. They exist in a state of active Brownian movement, which is caused by the impact of the moving electrons of the suspending medium on the particles. The smaller the particle the more vigorous its movement, since it is more liable to be struck irregularly. The charge carried by these particles in the blood is negative, and in health, since all

are charged alike, they tend to repel each other. If the charge becomes positive from loss of electrons they may tend to agglutinate, since unlike charges attract. Thus we find that the blood is slightly alkaline in health. Should the charge of these particles change one way or another from their optimum, disease begins. On the one hand we have a deficiency of electrons, which tends to send certain essential salts and other compounds into solution. The blood contains relatively too many hydrogen ions, and is more like a true solution than a colloidal suspension. Broadly speaking, it is acid although, owing to the complex buffer mechanism, this feature may not be obvious on testing the pH.

On the other hand, should the blood have an increased number of electrons there would be too many condensed in the particle itself for the free interchange of energy. Energy now, instead of being easily available, is tied up and unavailable for use. Picture, for example, a roulette-table at a fair. Normally one or two rows of people around will give easy access and provide rapid play. In our first condition there is a shortage of electrons or pennies and the crowd gradually disperses and leaves the table bare, so that the owner eventually packs up and it ceases to be a unit of the fair. In our second condition there is such an excess of people with pennies that those near the table cannot easily move on account of the rows and rows eager to make their stakes.

At this point you might well ask: What has all this got to do with dentistry? It seems a long way from atomic argument to the caries chaos. In a few words it is difficult to give anything but a limited review of the matter under consideration, but I can assure you that this electron business is the real fundamental factor of health and disease. However disguised may be the description, fundamentally all disease begins with a deficiency or an excess of electrons or atomic energy. If the balance is disturbed, correct it and disease vanishes. That, of

course, applies only if the correction is begun before the organs themselves have been irreparably damaged. Now, you may well say, how can such a weeping statement be applied to our daily practices? That, I admit, is not quite so simple as the making of the assertion but fortunately for us a large number of patients fall into the simple or early state of disturbance, and thus our work is simplified in a considerable proportion of cases.

To ascertain accurately the electrionic state of the blood a number of complicated biochemical tests are necessary. By these can be found at what point the protein particle is affected — and so the necessary degree of correction can be applied. Full consideration must be left till a later chapter, but the description of a simple test will help the reader in a preliminary survey and show how to obtain a fairly accurate indication of the state of the blood clinically and chemically. The saliva is an easily accessible fluid and usually mirrors the state of the blood in a surprisingly accurate degree. The normal saliva pH is 6.8, so the bromo-thymol blue indicator will suffice for all our dental needs; its range is from 6.0 to 7.6. A small quantity of saliva is drawn into a capillary tube with a rubber bulb and deposited in a small watch-glass. A corresponding quantity of the indicator solution is now mixed thoroughly and the resulting colour or tint compared with the range of capillary tubes described fully in a later chapter. The corresponding colour is marked with the appropriate pH value, so the test is complete. The treatment merely consists of alkalinising the acid and acidifying the alkaline. That is easily achieved by large doses of bicarbonate of soda or ammonium chloride. Should the patient not react favourably to treatment it may be necessary to apply further tests and treatment, or in very difficult cases to send the patient for consultation to a specialist who understands and can carry out further tests and indicate further treatment. Chemically, let us consider the

acidotic first. These patients are usually the fair-haired, red-complexioned, energetic type, the sympathetic dominant. There often is a gingivitis. The pH of the saliva may be anywhere on the scale below 6.8. These are the cases of rapid soft decay often with a yellowish tooth. Under treatment the dentine and enamel definitely get harder and less sensitive to deal with when excavating. These cases are deficient in electrons.

On the other hand, the group giving a saliva reaction of over 6.8 are more difficult to deal with. These are usually composed of dark, thin people. The gums are purplish. There is a tendency to catarrh. This class as a rule does not prove so amenable to treatment as does the former. The condition is an excess of electrons, which are tightly locked up and not easy to put into circulation. It is in this class that the true pyorrhœa is found.

This differential diagnosis between gingivitis and pyorrhœa is of paramount importance — it is comparatively rarely that the diagnosis thus reached will not be confirmed by a bacteriological examination. It also forms a valuable indication as to which type of patient one is treating. Let us now consider the blood picture and how it can be examined. The original ultra-microscope consisted of an optical bench projecting a beam of light into a cell at right angles to the microscope. As this method was cumbersome and unwieldy, Zsigmondy, a German chemist working in collaboration with Zeiss, developed an illuminant on a similar principle to the old type of paraboloid dark-ground condenser. The difference is that instead of a paraboloid reflector a spherical one is used, the effect being that the illumination reaches the object from a better angle, giving greater luminosity to the object examined and a completely black, dark ground. This cardioid condenser can be used with any good reliable high-powered microscope in conjunction with suitable lenses, giving a magnification

somewhere in the region of 2000.

As it is difficult to understand the ultra-microscopic picture of the serum with the terms acidity and alkalinity, McDonagh uses the words dehydration and hydration respectively. Dehydration is equivalent to a deficiency of electrons, i.e. acidosis, increased calcium-potassium ratio, sympathetic dominant, caries, and gingivitis susceptibility, and is shown in the serum by a breaking-up of the particles. Hydration, on the other hand, is equivalent to an excess of electrons, alkalosis, increased potassium-calcium ratio, parasympathetic dominant, pyorrhœa susceptibility, and caries immunity. Here there is an acquisition of too many ions by the particle, which increases in size and becomes a mass of bound-up energy not easily liberated, and in consequence the serum itself becomes less a solution and more like water.

Unfortunately for the easy understanding and application of the theory, these two states almost invariably exist together. That is, if some particles go into solution some of the near-by particles, with a strong charge, adsorb some of these constituents and become hydrated. If this mixture is present to any great degree, it is first necessary to deal with the upset causing distress and then correct the other features.

Dental medicine is yet in its infancy, but I think even at this stage it is a powerful weapon in our fight against disease. If you try it out for yourselves you will doubtless have your failures, but You will be agreeably surprised at the improvement you will effect in the general wellbeing of quite a number of your patients. Start with your saliva test for acids and alkalis, and as you meet failures do not get disheartened but get curious as to why your failures are not successes. By doing this you will increase your successes, and eventually regard electronic medicine as an established part of dentistry. Dental surgery and dental medicine are not antagonistic, but rather they can work hand in hand to conquer disease.

Unfortunately, it is not expected that any of this generation will live long enough to see the people of the earth well enough to dispense entirely with dental surgery, but I do think that suitable cases can be so controlled by preventative treatment as to reduce the incidence of dental disease to a minimum. Soon, I hope, the dental specialists will be paid to prevent cavities appearing in teeth as well as being paid to fill them. When dental medicine is accepted generally, we, as dentists, will no longer be regarded lightly by doctors and as a joke by Punch. Then we really will come into our own, and be respected as knowing how to prevent diseases, which at present our hopelessly inadequate methods cannot even control. Then, too, will dentistry become the first outpost of medicine, because in our position as dentists we see in the mouth the first evidence of this upset of the blood serum which eventually leads to organic disease. A dream, you may say; but I can honestly assure you that I have seen results so remarkable in a short space of time in many cases that the matter cannot be explained by coincidence. To me it is no dream but a practical science, which is awaiting your use and investigation. By applying the truths indicated in this book you will do good to your reputation and help to make the health of the nation improve — and the world will be a better place for your having lived therein.

Note.— This chapter is a modified form of a communication given to the Public Dental Officers Group, Southern Division, of the British Dental Association, at Winchester, 19th September 1936. It was later published in the British Dental Journal (15th January 1937). Acknowledgment is therefore due to the Editor of that journal for permission to insert here.

CHAPTER VIII

THE COLLOIDAL BASIS OF LIFE

Having outlined in the previous chapter the main principles of the story, it is now necessary to review the details at some length. A concise statement of the fundamental basis of dental medicine has been given by Broderick (1936). He has "for years contended that dental caries and pyorrhœa come into the same ætiological category; that they depend primarily upon vegetative disturbances in opposite directions. The former in the direction of sympathetic excess, with an excess of 'H' ions over those of `OH ' and an excess of calcium over potassium, an excess of thyro-adrenal activity, and a tendency to the break-up of the colloidal system (dehydration). Whereas pyorrhœa depends upon a disturbance in the opposite direction: an increase in vagal tone (parasympathetic excess), and increase in `OH' ions as compared with `H' ions, an overbalance of potassium over calcium, a diminution of thyro-adrenal activity, and a hydration, a tendency to enlargements and precipitation of the colloidal system."

Herein we find the principle of Aristotle applied, after nearly two thousand years, to one of the most common scourges of humanity, namely, Dental Disease. The truths stated above have been elaborated in many papers and books given to the dental and medical professions in the last few years. There is no shadow of doubt that such an outlook is gaining considerable ground in recent times. A similar thought forms the basis of McDonagh's works, although with his extensive knowledge of organic chemistry and physiology it is not quite so easy to follow. In this chapter it will only be possible to give a bare outline. If the reader thinks this

inadequate he is referred to the works mentioned in the bibliography.

"Disease," McDonagh (1927) says, "is the signal of defeat suffered by the protective substance at the hands of the invader. There is only one disease and one invader, and the struggle between them is of all electrical nature. The object of treatment is to increase the electronic activity of the protein particles in the plasma. Treatment is successful when it increases the number, Brownian movement and negative charge of the protein particles, because by doing so it increases the surface and consequently the electrical energy of the protective substances. When the invader, be it a micro-organism or a chemical poison, robs the protective substance of electrons, some of the protein particles split up preparatory to going into true solution, while others increase in size and agglutinate. These changes can be covered by the word 'condensation.' Successful treatment increases the electronic activity of the protective substance by conducting electrons to the protein particles. The changes which the particles undergo as the result of this conduction can be covered by the word 'dispersion.'

To further clarify the visualisation of the happenings in the plasma, we must define the picture of the protein particles to the reader's mind. This is also best given in McDonagh's (1927) own words: "A protein particle can be likened to a solar system in which the sun is represented by the protein nucleus and the planets by the structures which go to make up the complex, these being electrons, inorganic salts, urea and uric acid, sugar, amino acids, and fat. In detail the analogy is not quite so close, because while the planets move round the sun they do so always in the same path. The protein planets form a more or less intimate connection with the nucleus, and there are many intermediary substances between the individual planets and the sun. Furthermore, the intimacy of the

connection is influenced by various physical conditions. In other words, the planets may be loose-held, or tightly held or even enveloped.

Such is his description of the protein particle or molecule. The formation, therefore, could possibly be more clearly depicted by the structure of an onion. Each layer surrounding the inner structure could be likened to a layer of smaller molecules arranged in a definitely oriented arrangement, each providing a shell or skin of material which suggests a similarity at once to the structure of the atom with its central nucleus and succeeding shells or orbits of electrons.

As we have seen, the inner shells of electrons in atoms can be altered in certain circumstances. The alteration of electronic structure has been shown to effect either a liberation or binding-up of energy. This, because the electron is to all intents and purposes a form of energy. It may also be noted that this energy factor is one which has been neglected to a very great extent in the arrangement of chemical formulæ. At this point we should realise that the energy part of the equation has to a very great degree been neglected by medicine.

These protein molecules, by virtue of their size and atomic arrangement, act in the plasma as do the particles of other mixed colloidal hydrosols. The blood being probably the most complicated and most studied substance in this group, it is surprising that more attention has not been previously given to the colloidal make-up of this fluid. It should now be obvious that these protein particles act as reservoirs of chemical and electrical energy: as accumulators can store electrons in the form of a charged chemical potential, and can liberate them when required, and as hæmoglobin in the blood corpuscle can store oxygen in the form of oxy-hæmoglobin and can exchange this oxygen for carbon-dioxide, can carry it to the lungs in the form of carboxy-hæmoglobin, where an exchange

again takes place.

The conditions which bring about the movement of electricity in the accumulators and oxygen and carbon-dioxide in the case of hæmoglobin are easily defined by one word, "potential," the action of the accumulator depending merely on pressure and direction of flow of the electrons in the circuit to which it is connected. This pressure causes a storage or a liberation of electrical energy. The condition is on a par with condensation and dispersion referred to earlier in this chapter. The hæmoglobin acts in a similar manner, but here it is not merely a question of electrons or electrical energy. Here we have an interchange of somewhat different calibre, notably that of two dissimilar gases which can be adsorbed into the corpuscle complex. In the lungs the oxygen is absorbed through the wall and loosely combined with the large molecule of hæmoglobin. It is then pumped through the tissues until it meets a part of the body structure which has a greater need or affinity for oxygen, the oxygen is then grabbed, and the hæmoglobin feeling unsatisfied adsorbs the next best in the form of carbon dioxide. This in turn is passed back to the lungs, and the potential there is such that the carbon dioxide is liberated and fresh oxygen supply is adsorbed to continue the cycle. At this point it is of interest to note the electronic structure of the oxygen and carbon dioxide, so the reader is referred to fig. 6 for details. It will then be seen that carbon dioxide is a non-polar compound, and, as the whole structure is deficient by four electrons, to make up the full three shells of eight complete external electrons, the oxygen and carbon atoms are each therefore sharing two borrowed electrons and arranged in such a manner that each atom is surrounded by the full quota of eight. Take away the carbon atom with its four electrons and the two oxygen atoms now share two electrons to complete their outer shells with the formula O_2 . The combination of oxygen and carbon in the body liberates

energy; energy is adsorbed from the atmosphere and sun rays in plants when the carbon is removed from the carbon dioxide molecule, and the oxygen is once more sent back into the air reenergised and ready to fulfil its function in again supplying energy to the animal bodies.

Coming back to the protein molecule, or in other words, the colloidal particle of the blood plasma, we have seen that it is of a very complex arrangement or condensation of potential energy in the form of atoms and molecules grouped in layers as previously indicated. This particle has by virtue of its adsorptive properties the power of attracting to it various constituents which penetrate the bowel wall by osmosis. Osmotic pressure seems the only possible explanation as to how particles of nutriment get through the intestine into the blood stream. Any unexplained assumption that they are just absorbed seems ineffectual. Therefore the osmotic balance on both sides and the state of the bowel wall may explain how sometimes diets and drugs do not always have the expected or desired results.

The constituents once in blood-stream, if the particles are in good condition, are adsorbed and held in a comparatively loose manner, which enables the atoms to be given up to the various cells and tissues which have need of them. Two disturbing states may alter this happy and free exchange of atoms. In one case the particles may lose their power to adsorb and therefore lose their various components. This happens in early disease and results in the adsorbed constituents going into solution or lysis. McDonagh refers to this state of the particles as dehydration, because he says that water amongst other factors is thrown out of the particle complex. The result on the serum is that, as the particles break up, the materials are dissolved in true solution and cannot then behave as colloidal hydrosols. This state is one equivalent to acidosis or deficiency of electrical energy. Owing to the fact

that in life the pH of the blood cannot vary greatly, this fact seems to have been missed. It is the amount of potential energy contained in the plasma that matters, and if this is not in a state of colloidal suspension the free interchange of atomic energy essential to health is lacking. This results in the incomplete working of an organ or organs, and probably the eventual destruction of the parts affected by a breaking-down or tendency to liquefaction.

On the other hand, the particle increases in its power to adsorb or hold other constituents, including water, to which McDonagh refers as hydration. The components are withdrawn from the blood plasma into the structure of the protein molecule, leaving the liquid more like pure water, and the particles grow larger and unwieldy with a tendency to go out of solution by precipitation. This causes a blockage of the smaller capillaries and arterioles with a stoppage of the blood supply to an organ or part of an organ with resultant dysfunction.

The Doctrine of the mean can be clearly distinguished at this stage. The deficiency of electrionic energy produces a potential acidosis, which results in a breaking-down of body structures. Energy being too free, it is easily dissipated. The opposite condition, of an excess of electrionic energy, creates a binding-up or condensation of the same forces, which tends to make the liberation of the vital forces a matter of difficulty.

As will be seen later, the whole matter may not in practice be quite so simple, but the structure of dental medicine depends for its foundations on the above-stated principles.

CHAPTER IX

SIGNPOSTS OF DISEASE

It might be expected from the previous chapter that there should be ways and means of determining the type and degree of electrionic upset in the body. There ought to be some signposts, or "you have been warned" notices, erected by Nature to indicate when the body was getting out of order. Up to date, established disease has been the only indication, generally recognised by medical men, that a body was not functioning properly. Then, unfortunately, it is often too late. Disease means an already established evil, with all organ partly or completely destroyed. We can expect little help therefore from orthodox medicine in looking for early signposts on the way to ill-health.

There are, no doubt, many slight indications, but they are for the most part considered almost trivial in nature. Slight symptoms, which should tell the individual when his balance is becoming upset, are undoubtedly present. In many cases these are, unfortunately, ignored or not noticed. For the present our attention will be concerned with the ways and means of diagnosing the type of upset and its degree of severity. In a later chapter the early physical symptoms will be dealt with at length.

The purpose of this chapter is, accordingly, to put before the reader a brief but sufficient description of the biological tests which can be applied to determine the state of electrionic activity present.

The Salivary pH

Fortunately for the dental reader the saliva mirrors to a surprisingly accurate degree upsets in the metabolic balance of the individual in a large number of cases; especially those early cases where disease has not progressed too near its end-point.

This is a statement which has on many occasions been the cause of much controversial verbosity. Be that as it may, personal experience will soon show that the salivary pH does vary, and it should therefore be of great assistance for diagnostic purposes.

The "pH value" is a number used to express the active acidity or alkalinity of any fluid. The figure used gives an indication of the concentration hydrogen-ions in solution. Water with an equal quantity of H and OH ions is neutral, because there is no excess of one ion over the other. Cocking gives the following figures: deci-normal (0.1 N) hydrochloric acid has a hydrogen-ion concentration of 10^{-1} , i.e. 1 litre contains 0.1 gramme of ionised hydrogen. Deci-normal sodium hydroxide has a concentration of $10^{-13.07}$. One litre contains therefore only 0.000,000,000,000,0.86 gramme of ionised hydrogen. These figures are inconvenient, and therefore the index figure is taken alone without its negative sign. The scale runs from pH 0.3 on the acid side to pH 14.5 on the alkaline; pH 7 is about midway and is usually taken as neutral. The actual neutrality figure taken as standard is that of water at 18°C., which is pH 7.07.

An acid, it must be remembered, gives a figure less than 7 and an alkali greater. This is because the scale used is an inverse ratio figure and really indicates the negative power of the figure given. It can be concluded from the foregoing that each whole number marks a concentration equal to one-tenth that of the preceding whole number. Therefore each 0.1 increase of pH value actually represents a 10 per cent. (approximately) decrease in hydrogen-ion concentration. This may appear strange, but it must be remembered that the pH figures are really logarithms. For example, a pH of 6 indicates 0.000,001 gramme of ionised hydrogen per litre, whereas a pH of 5 indicates 0.000,01 gramme. Whereas pH 0 indicates 1 gramme of ionised H per litre; pH 0.1 = 0.8 gramme; 0.2 = 0.63 gramme; 0.3 = .05 gramme; etc., etc. Readers are referred to Broderick (1936) and Bilham (1937) for further information.

The reaction of saliva in spite of many statements to the contrary may and does vary within quite wide limits. The proof of this lies in the test, which is a simple one and easily applied. The British Drug Houses Ltd. supply a capillator for this purpose. A dozen or more different types are obtained for various ranges and reactions. For saliva tests the bromo-thymol blue, giving a range from 6.0 to 7.6, does all that is required by the dental physician. The normal figure for saliva, being slightly acid, is 6.8.

The capillator under consideration consists of a small pipette, watch-glass, bottle of indicator, and a card of matched capillary tubes, filled with an indicator suitably graded for colour. The method requires that a few drops of saliva, collected from the mouth or in a dappen glass, are drawn into the capillary tube with a rubber bulb up to a graduated mark. This is now discharged into the watch-glass. An equal quantity of the indicator is now mixed and the resultant colour compared with the standards, and the pH value is read off the card.

The test is simple, inexpensive, and occupies only a matter of two or three minutes in all. Sometimes a case will be met when the saliva will show a colour not in the scale on the card. This does not matter materially, as colours are from yellow on the acid side through green about half-way, to blue on the alkaline range; and if the colour should be off the card it is an easy matter to ascertain which way it lies. The actual amount does not alter the treatment required to bring the patient back to the correct point. To know whether it is yellow or blue, acid or alkaline, is the important consideration.

The reason why some salivas, notably those with a lot of foreign protein matter, in certain types of obviously 'acid' or 'dehydrated' patients give an alkaline result can be easily explained. Protein particles bearing a negative charge behave to indicators as alkaline although they may be quite low in electrical activity; in other words, the molecular arrangement

may be such as to disguise in some degree their actual capacity. Although fundamentally at some low ebb in electron content, they may be able to donate one electron or more to the indicator ion and so give an apparently alkaline result. This does not mean, however, that they will be able to behave in the same capacity to the tissues of the body whose electromotive force may not be of the same degree of affinity as the indicator.

Height-Weight Ratio

This gives some indication of metabolic balance. The formula gives a useful comparison of the ratio of anabolism to katabolism. The figure is found by dividing the weight in pounds by the height in inches.

$$\frac{\text{Weight in pounds}}{\text{Height in inches}} = \text{H.W.R.}$$

In children, Broderick (1936) gives as the normal figures about 1.6 to 1.7, and for adults 2.3 to 2.4. An increase in these figures is suggestive of anabolic or parasympathetic excess. A decrease suggests katabolic overaction.

Blood Pressure

This is an indication of contraction or dilation of capillaries as a result of dehydration or hydration respectively. The apparatus consists of a U-tube of mercury connected to a rubber bag. The later is placed around the biceps and bandaged loosely to allow expansion without slipping. The rubber bag is inflated with a small hand-pump while the operator listens to the heart-beats in the ante-cubital fossa or feels the pulse. At one point of inflation the beat ceases and the reading is taken. The pressure is then slowly reduced with a valve, the beats return and get louder, and later diminish and then cease altogether. The reading is again taken. The two readings give systolic and diasystolic pressure respectively.

The systolic pressure is about 100mm. of mercury at birth and increases about 1 for each year of the patient's age. The diastolic is about 40 below the systolic reading. An increase suggests dehydration with its concomitant contraction of arterioles. A decrease is suggestive of hydration with its accompanying relaxation of the arterial walls. In advanced disease these findings may have a different interpretation.

Pulse Rate

This also indicates dehydration and hydration. The pulse rate and the blood pressure have in common their ability to indicate the ease or difficulty of pumping blood through the tissues. If the pressure is high owing to the contraction of capillaries it can be taken that the heart has to pump more often to maintain the circulation. This can be taken as suggestive of dehydration. A lower pulse rate can therefore be taken to denote the opposite state of affairs.

The average rates per minute are given below for different ages:

0-1 year	130 per minute.
1-2 years	115 - 120 per minute.
3-4 years	105 - 110 per minute.
t>-9 years	95 - 100 per minute.
9-10 years	90 per minute.
16-17 years	80 per minute.
Adult	70 - 80 per minute.

A quick pulse and a high pressure suggest thyro-adrenal over-activity, dehydration, or acidity. A slow pulse and a low pressure suggest thyro-adrenal inactivity, hydration, or alkalinity.

The Blood Plasma

The difficulty of applying any tests to the plasma in situ can readily be appreciated. Immediately it is withdrawn the

atmosphere and changed environment bring about a gradual dissipation of electronic energy. Nevertheless if that fact is borne in mind a number of tests will give useful indications of the electronic state of the blood. Briefly the tests described hereunder all give a comparison of dehydration to hydration. It often happens that a number of tests may show apparently conflicting results. Having performed whatever tests the operator deems necessary, he must then decide the predominating influence, together with its degree of intensity, and treat his case accordingly. The most useful tests, the macro- and ultra-microscopical examination of the serum, are of such importance as to warrant a special chapter, and will accordingly be dealt with later.

As has already been pointed out, the constituents of the protein micellæ in the plasma are arranged from within out - positively charged nucleus, fats, amino-acids, sugar, uric acid and urea, inorganic salts and electrons. To apply tests one must realise the importance of these considerations. In dehydration there is a tendency for the particles to break up and the constituents to go into true solution, and later they may be deposited in the tissues or voided in the urine. The finding therefore of a greater quantity of any of the constituents than normal in the plasma indicates the degree of penetration the upset has had upon the particles. Hydration, on the other hand, will lead to a fixation of the constituents to the protein molecule with a consequent withdrawal from the plasma. Bearing these two phenomena in mind we can now use the various serum tests to assist in our diagnosis.

Viscosity

The viscosity or stickiness of any liquid is an indication of its colloidal nature. Consequently it points to any tendency to change towards solution if lowered; or, on the other hand, to an increase in internal molecular attraction if rendered more

colloid. Many instruments are available for the purpose. All consist of timing the flow of the liquid to be tested in a capillary tube or through a measured orifice under constant conditions of temperature and pressure. The serum has, as a rule, a normal viscosity of about twice that of distilled water. In the acute stages of disease there is usually a tendency to find a lowered viscosity. In chronic disease the reverse is often the case. Drugs, such as calcium, which tend to increase the number of particles may cause a fall in viscosity.

Surface Tension

This is a difficult test to apply owing to the fact that it requires a large amount of serum and the difference in readings is small. If the blood is collected for examination in one of the pipettes, described in a later chapter, some indication of the surface tension can be obtained from examination of the meniscus of the blood. The surface tension must be differentiated from the internal tension of a liquid. The internal tension will be increased by hydration, whereas surface tension will be lowered. Dehydration shows the reverse characteristics. A rise in surface tension is suggestive of dispersion or solution, a fall suggests condensation. A high surface tension shows by a deep concave meniscus at the surface of the blood, a low surface tension on the other hand would tend to be flat or may be in extreme cases slightly convex.

Suspension Stability

The suspension stability or rate of fall of the corpuscles in a citrated or oxydated serum gives an indication of its electric content. McDonagh's (1926) method is to use a tube 17mm. long and 9mm. in diameter. In this is placed 2.0cc. of sodium citrate (2 per cent) to which 7.0 c.c. of blood is added and the tube shaken. The tube is then stood upright and the fall in the corpuscles measured by the height of the column of clear

serum at the top of the tube.

Broderick's (1936) method is simpler and needs only a small quantity of blood. A small block of wood is recessed to hold a knob of plasticene, and has an upright back with a scale graduated in millimetres for about 10cm. A large hard-glass capillary tube open at both ends and about 11 cm. long and 1.5mm. internal diameter is washed out with potassium oxalate and filled with blood to about 10 cm. This is well shaken, the fingers can cover both ends while this is being done. A finger is held over one end to prevent the blood running out and the other end stuck in the plasticene, and the tube is left upright for one hour. For the sake of accuracy it is better to time this with an alarm clock. The reading is then taken as before. The normal fall is about 1.5 to 2 cm. A greater fall is an indication of lack of electrionic activity - or dehydration; whereas in hydration it may appear to be normal or even less. If the corpuscles sink quickly, the plasma is poor in electrons; if slowly, it is rich. The activity of the moving electrons contained in a negatively charged hydrosol protects the corpuscle from the action of gravity and retards its fall.

Inorganic Salt Content

A great, deal of information about the inorganic salts present can be obtained from the ultra-microscope and will therefore be dealt with in the chapter devoted to the description of that instrument. Owing to the small nature of the atoms composing these substances it is likely that they percolate readily through kidneys, sweat glands, and other tissues. One would expect a greater content of salts in dehydration than in hydration, but, generally speaking, the cases in which salts are found in excess are usually those of light rapid dehydration, or, on occasions, alkali-poisoning. The normal blood pH is 7.4, but Cope (1936) records pHs of as high as 7.6 in certain cases of poisoning, owing to ingestion of large quantities of alkalis.

Alkali Reserve

The quantity of alkali in the blood gives an indication of its ability to buffer the waste or acid products of metabolism and katabolism. Chemical tests employ careful titration. Broderick's method (1936) is: One or two c.c. of blood is withdrawn and mixed with a small quantity of anti-coagulant (e.g. sodium or potassium citrate or oxalate) and centrifuged; 0.1 c.c. of the serum is placed in a small beaker and 0.5 c.c. of N/100 hydrochloric acid added and gently shaken. This is next exhausted under a negative pressure of about 30 inches of mercury for about a quarter of an hour to remove any carbon dioxide. The mixture is then titrated with N/50 caustic soda to a definite point, say 7.4 on the pH scale of phenol red. (This indicator and endpoint are chosen because there is a definite change from red to purple which can easily be observed.) This result is compared with the titration of 0.5 c.c. of N/100 hydrochloric acid. The difference indicates the amount of alkali present in 0.1 c.c. of serum. In order to facilitate titration of these small quantities, 2 c.c. of neutral normal saline should be added to each vessel of acid. In order to get a sufficiently accurate result it is necessary to use a micrometer pipette, which is similar in many respects to a hypodermic syringe, but is controlled by a fine screw which give accurate measurements by thousandths of a c.c. The final figures are obtained by subtracting the result with the mixture from that with the hydrochloric acid alone and multiplying this by 2. The result is given in millimols, and the normal limits are between 24 and 28. A low figure indicates an acidosis and a high one an alkalosis.

Van Slyke uses a large quantity of blood mixed with an anti-coagulant and centrifuged. A known quantity of serum is subjected to saturation with carbon dioxide under pressure. A known amount of lactic acid is added. This is able to liberate the carbon dioxide, adsorbed by the bicarbonates, but does not

affect the more stable carbonates. The evolved gas is measured. The three amounts known enable the operator to calculate the volume of CO_2 that would be evolved from 100 c.c. of serum at S.T.P. This gives the combining power of the blood with CO_2 . It is measured obviously in volumes per cent. The normal values are between 53 and 77. Again a low figure indicates an acidosis and a high one an alkalosis.

Further information may be indicated more simply by clinical history and the ultra-microscopic examination of the freshly extracted blood.

Blood Sugar

The amount of blood sugar present gives a valuable indication of the absorption power of the particles for this substance. There are several methods employed, but MacLean's (1922) is fairly widely known and often applied. Details of the test may be obtained from a leaflet on blood sugar issued by The British Drug Houses Ltd.

The general principles of the reaction are as follows. The blood is heated with a saline solution to remove the main protein constituents by coagulation. The remaining traces are then separated by the addition of dialysed iron. The sugar in the clear protein-free filtrate is estimated by boiling with an alkaline copper iodine solution, containing potassium iodide and iodate. The cooled solution, containing reduced cuprous oxide, is treated with a small excess of sulphuric acid. Iodine equivalent to the amount of potassium iodate is liberated. The cuprous oxide is dissolved, forming cuprous sulphate. Being very unstable it is at once oxidised by the free iodine present. The amount of sugar originally present is obtained by estimating the amount of iodine used up in the foregoing reaction. This is easily obtained from a table given in the leaflet mentioned above. The average result for human blood is about 0.131 to 0.081 per cent. This may vary slightly according to the method

employed for determination. A fall in the figure indicating adsorption of the sugar molecule by the protein particle is suggestive of hydration. On the other hand long-standing dehydration may not always give an increased figure owing to the elimination of sugars in the urine and other factors.

Blood Urea

The blood urea test is somewhat complicated and need not be described here. Readers who require further information are referred to MacLean (1922). The normal percentage is from 40 to 60 mgm.; an increase indicating dehydration and a decrease hydration. The injection of metallic ions may tend to increase the percentage of urea in the urine, whereas non-metals tend to reduce the amount. Details of this are given by McDonagh (1926).

Refractive Index

The refractive index is the ratio of the angle of incidence of a ray of light to the angle of refraction. This is found by mean of an Abbe refractometer, an expensive piece of apparatus which gives a micrometer scale reading of the result after various adjustments have been made. A drop of serum is placed between two prisms and the scale rotated until two areas of colour coincide in the viewing lens. The pointer then gives the desired result on the scale. A greater content of dissolved substances will give a smaller figure, whereas a more colloidal solution tends to give a larger figure. Bostoc (1929) gives the normal values in healthy persons between 1.348 and 1.351. The indications of dehydration and hydration are obvious. A fall in figure is suggestive of dehydration. Broderick (1936) shows that an increase indicates hydration or increased globulin-albumin ratio.

The R.I. of the urine may also give helpful information. Normal urine is about 1.3398. This figure is lowered in

dehydration, which damages the glomeruli of the kidneys. It is raised in hydration, which tends to damage the convoluted tubules.

Urobilinogen

The bile pigments undergo bacterial decomposition in the the large intestine with the formation of stereobilin, the pigment of the fæces - Bainbridge and Menzies (1920). Some of this is reabsorbed and appears in the urine as a chromogenic substance, urobilinogen, from which urobilin is formed by oxidation. This process is chiefly noticeable in pernicious anæmia and other conditions in which there may be destruction or lysis of the red blood corpuscles. Urobilin shows an absorption band at the junction of the green and blue part of the spectrum. It also gives a green fluorescence with zinc chloride and ammonia.

Erlich's aldehyde reaction is more reliable and is performed as follows: Two grammes of dimethylpara-amino-benzaldehyde hydrochloride are dissolve in 98 c.c. of a mixture of hydrochloric acid 4 volumes and water 1 volume. To 5 c.c. of urine add two drops of the solution. A deep red colour is positive for urobilinogen or urobilin. It may be necessary to warm the tube, and it often takes a few minutes for the colour to appear. A positive result on this test is indicative of comparatively severe dehydration, which is sufficiently powerful to send the blood corpuscles into lysis; it is also suggestive that the bowel elimination is slower, thereby causing excessive absorption of bile pigments into the blood-stream.

The Ultra-microscopic Examination is of such importance in relationship to the serum colloids as to warrant a special chapter. Attention is therefore directed to the use of this instrument and some of the findings obtained therewith in the next chapter.

CHAPTER X

THE ULTRA-MICROSCOPE

In order to appreciate the true beauty of colloidal solutions one has to view them through the lenses of an ultramicroscope. Colloidal argentic chloride (Crookes) surpasses most sol for sheer loveliness. Imagine if you can myriads of tiny scintillating globes of brilliant blue-green, dancing merrily against a black background. Calcium (Crookes) has much smaller particles, which look more like minute tufts of cotton in lively motion. Blood serum exhibits its own characteristics, as one examines the shimmering particles, which are present in various numbers and sizes according to the state of health of the patient. Unfortunately the dark-ground observation of blood has been neglected by the majority of biologists. In the present work the reasons for the conclusions reached are given as completely as possible, but as more work is done other ideas will tend to develop. Let us, start therefore, at the beginning, to do which it will be necessary to describe the apparatus required and its uses.

Zigmondy (1909) in his early researches used a form of slit ultra-microscope, the principle of which was to direct a powerful beam of parallel ray into a liquid and examine the particles thus revealed through a microscope, the objective of which was immersed in the liquid to be examined. The fine focusing was done by movement of the ray pencil. There are several makes of instruments of this type available to-day, but they need a large amount of solution and very careful manipulation and in addition the magnification obtained is relatively small.

In order to make the examination of small quantities of sols

a simple operation, Zsigmondy, working in collaboration with Siedentopf, evolved the cardioid ultra-microscope. This consists of a special type of dark-ground condenser giving exceptionally clear definitions combined with ease of working and high resolving power.

The Ultra-microscope. — The optical system used by the author consists of a Zeiss E.S.C. stand, 20 x compensating eyepiece, an achromatic objective 1/12 (N.A. 1.25) with iris diaphragm, in conjunction with the cardioid condenser detailed above.

The Illuminant. — Although the makers recommend the use of an arc lamp for illumination, consistently good results have been obtained with a 12 volt x 36 watt motor-car bulb worked off a small transformer. The transformer output gives 3 amps and is tapped on a sliding control for 12-13-14-15-16 volts, giving a very intense illumination when required and compensates for line-voltage drop at certain times of the day. For general purposes 12 volts is generally ample to illuminate even the small particles found in dehydrated blood. With a step-down from 200 volts to 12 volts there is a consumption of a very few watts off the mains, which results in a considerable saving of current over an arc lamp requiring anywhere from 5 to 10 amps overall.

The latter also develops an enormous heat with which it is uncomfortable to work for long periods of time. The light rays from the lamp are focussed by means of a bull's-eye condenser and a pair of lenses, which result in a beam of almost parallel rays on the plane surface of the mirror. The optimum working distance from the lamp to the mirror is about 10 inches, but may have to be varied slightly according to the arrangement of lenses employed. The beam or pencil of rays is controlled by an iris diaphragm, which alters the diameter of the spot falling on the mirror surface. This iris is not really essential, but it does give a finer control of the illumination intensity than can be

obtained by the adjustment of the substage or objective iris alone.

The spot of light should be about the size of a shilling or less on the mirror; this is then reflected on to the hemispherical silvered reflector, which is about $\frac{1}{4}$ -inch diameter, in the condenser. The rays are now bent outward to the circumference of the condenser's upper lens and there bent inwards; this time they meet concentrically at a very fine point about one millimetre above the surface of the top of the condenser. The angle of convergence is nearly at right angles to the long axis of the microscope tube, the result being that when correctly adjusted the objects viewed stand out clearly illuminated on a perfect black background.

The Cardioid Condenser. — The best type of condenser for the work under review is the Siedentopf 1.0 N.A. Cardioid Condenser with centering device, manufactured by Carl Zeiss of Zena. It has been especially designed for the ultra-microscopic observations of colloidal solutions. Moreover it is well adapted for the dark-ground examination of aqueous subjects, bacteria, and also for photomicrography, being both achromatic and astigmatic. The centring device consists of two eccentric bushes, which, when rotated, enable the light spot to be brought into correct alignment with the objective lens, which on high powers, is very small. This is fixed into the substage so that the upper surface of the lens comes a small fraction of a millimetre below the main stage level, thus avoiding accidental contact with the slide and consequent damage to the slide or condenser. The old type of dark-ground condenser, notably the paraboloid, scatters its light over a large area and does not give such crisp sharp results as the type just described. Nevertheless it is quite possible to use it and get quite a lot of useful information therefrom. The paraboloid is more suitable for use with lower powers which, for the examination of serum colloids, are not so effective.

The Slides. Owing to the fine focal point of the condenser it is almost imperative to use slides which have a standard thickness of 1.0 mm. A slide with a thickness of more than 1.2 mm. will cause a lot of unnecessary focusing and adjustment, and, even if after a lot of manipulation anything can be seen, it will be inadequately illuminated. In colloidal work it is important to use a good-quality hard glass. The cheap glasses sometimes cause a reaction in the sol with consequent change of appearance which must be avoided. Cheap glass slides can be bought at about 1s.6d. per hundred, and the best quality white plate with polished edges cost nearer 10s. As the slides can be cleaned and used again this cost is not very important.

The Cover-Glasses. — These can be obtained in many varieties. With a high-power lens the clearance is small, and therefore it is necessary to have a thin slide of good quality. The shape is a matter of fancy for the individual worker. They can be obtained either round, square, or rectangular in shape. The latter have no special advantage for this type of work. The square are quite satisfactory, but they are almost impossible to clean without breaking. In practice, therefore, the round ones will be found most useful. The diameter is important, for if the cover-slip size is too small there is a tendency, if the preparation has a high viscosity, for the slide to lift and spoil the preparation - 18mm has been found quite a useful size in practice. The larger sizes are somewhat expensive, and the smaller do not stay easily in position. 18-mm slips of good quality cost about 2s.6d. per 100.

It is important, in order to obtain the maximum detail, in resolution of the object, that the thickness of the cover-slide should be constant and chosen for the objective in use. Zeiss objectives are corrected for cover-slides of 0.17mm. Any large variation from this may cause an inaccuracy in the image seen. If no adjustment is provided on the objective, the influence of a departure from the correct thickness of cover-slip can to some

extent he neutralised by an adjustment of the tube-length. This may be effected by extending the tube if the slip is too thin, or shortening it if too thick. The former causes spherical under-correction and the latter over-correction, which are both noticeable with high-powered objectives. Ordinarily the tube-length of Zeiss microscopes is set for 160mm. which includes the 15mm. of the revolving nosepiece.

The Immersion Medium. — This material usually consists of cedar oil with or without other ingredients. The reason for its use is to provide a continuous path for the rays of as nearly the same refractive index as can be obtained. When light rays pass through two transparent substance of different refractive index, the rays are bent. In high-powered work, therefore, it is necessary to avoid all unnecessary bending of the rays, so a drop of cedar oil is placed on the surface of the condenser. The underneath part of the slide is touched with a drop of oil and gently placed in position, taking care to avoid all air bubbles. The presence of even a very tiny bubble will cause a scattering of rays, which may render focusing difficult or even impossible. A drop of oil is now placed on the cover-slip and the objective gently lowered into position. cedar oil should have a refractive index of 1.515, and any variation from this will seriously interfere with the fine detail required for colloidal work. Pure cedar oil is too thin, so it is usually improved by the addition of a small quantity of Canada balsam. This is then put in a gentle heat of an incubator for several hours to thicken. A reliable make should be used. The oil should always be cleaned off the microscope immediately after use, as old oil is a messy nuisance and can interfere considerably with the easy manipulation. Zylol lightly applied on a soft cloth removes old oil very effectively.

Special Slide for Colloids. — An Observation Chamber for the examination of colloids has been specially devised by Zeiss. This consists of a brass box with a circular ring screwed

into it. The ring holds in position a circular chamber of fused quartz glass about 20 mm. in diameter. The centre is optically worked so as to present a small central plateau a few microns below the upper surface of the chamber proper; round this is a groove to accommodate excess fluid when the cover-slip is placed in position. The total thickness of the quartz chamber is 1.0mm. The cover also is a piece of flat quartz about .75mm. thick. When a drop of colloid to be examined is placed in position and the cover adjusted, the brass ring is screwed in position so as to give a definite positive pressure and overcome any tendency of viscosity to alter the specimen thickness. Further details may be obtained from Messrs Zeiss's leaflet "Micro 306," from which the following quotation is taken:-

"It would naturally be cheaper to make the chamber of glass, but unfortunately glass fluoresces under the intense illumination furnished by the cardioid condenser. In addition, glass surfaces are much more liable to be affected by corroding agents, in consequence of which it can never be depended on to retain such perfect and clean surfaces as fused quartz. The cover must be made sufficiently thick to resist depression under the influence of adhesion and to prevent it from sinking upon the central portion. This would have the effect of dispelling the whole of the colloid particles from the fluid, causing them to be precipitated. The thicker cover-glasses have the further advantage of being less breakable and more easily cleaned. The surface of the central portion and the lower side of the cover-glass require to be very neatly polished in order that they may not impair the quality of a good preparation."

Although this chamber has the advantage of a constant preparation thickness to recommend it for comparative purposes, it has several disadvantages, which in the author's opinion render it inconvenient for the study of blood serums.

First, owing to the thickness of the cover-glass, high powered objectives cannot be used. The makers suggest a

glycerine objective 60, which is approximately 1/7th. Owing to the number of very minute particles in some blood serums, in practical work an objective in the region of 1/12th is much more effective. Secondly, the cost (just under £3) precludes having many chambers available for use in private practise, therefore if many serum examinations are done one must use slides as before described. Finally, they are clumsy to use and results just as good can be obtained with high-quality slides if carefully cleaned.

Care of Slides and Cover-Glasses. — Scrupulous cleanliness is absolutely essential in the preparation of any specimen in order to avoid changes in the colloidal state which might tend to cause an error in diagnosis. The usually recommended method for cleaning slides and glasses is boiling in soap and water, followed by washing and then boiling again in a strong solution of chromic and sulphuric acids; again washing carefully in running , preferably distilled, with a final drying by warming slightly in a Bunsen flame or hot-air blast. This method is quite successful, but it has been found in practice to cause corrosion of the slides with a consequent tendency to precipitate the colloids on the glass. It must be remembered that colloidal solutions are particularly susceptible to alterations in electric activity. A positive charge on the glass at any point would naturally tend to attract a particle with a negative charge. After the trial and rejection of the above and many other methods, it has been found that a more simple method gives best results. After the slides are removed from the microscope they are dropped into a glass jar, which was dubbed by one of the author's more humorous friends as the "Bug Grave." The jar contains a fairly dilute solution of Lux flakes with a small quantity of lysol. When a hundred or so slides have been used, they are washed in running water and wiped with a piece of wet linen to remove any deposits. They, are then boiled in soapy water for about ten minutes. The cover

-slips are given the same treatment, but separately, as they are easily broken if boiled with the heavier slides. They are then washed and wiped under running water and allowed to drain. Each slide is carefully polished with an absorbent non-fluffy cloth and placed in a box until required. It has not been found necessary to keep cover-slips or slides in alcohol and water, or alcohol, as is frequently done. Prior to using, the slide is gently wiped with a soft old linen handkerchief, a drop of sol placed on the centre, and the slip applied gently. The best test for a clean slide is its ability to spread a thin layer of water on the surface without its collecting in spots.

The Objective. — This lens, being the first of the system used, is of considerable importance. The large metallic colloidal particles can be seen with fairly low-power objectives, $1/7$ th gives tolerably good results and $1/6$ th or $1/4$ th suffice to show the particles. The serum particles are frequently smaller in size than metals and are always less luminous or retractile. Consequently a somewhat more powerful lens is required. For working with blood colloids a good objective of $1/10$ th or $1/12$ th will be necessary.

There are three main classifications of objectives. The apochromatic contains anything up to ten or more lenses and has the highest chromatic correction possible to obtain. The achromatic objective of good quality may have about six lenses and is corrected to at least two colours of the spectrum, and consequently is quite good for routine work on colloids. The third type, or fluorite, comes about midway between the other two in point, of correction for colour but not for spherical aberration. It is necessary to have an iris diaphragm fitted to the objective in order to obtain accurate control of light concentration required for colloidal work. A greater power than $1/12$ th necessitates such a close working to the surface of the cover-slip that it renders adjustments extremely difficult, consequently very high-power objectives cannot be

recommended for routine work.

The objective should be cleaned carefully with a soft cloth dampened with a little benzine or zylol. Alcohol should not be used as it may soften the shellac used for mounting the lenses and so may damage an expensive objective.

The Eyepiece. — This lens is not quite so important, as fairly good results can be obtained with any eyepiece of sufficient power. The best magnification is about 20 x, the addition of one about half that power, 10 x, is very useful if it is required to examine a larger field. The images of flat objects thrown by an objective are not plain but curved. This results in the lateral portions of the field appearing nearer to the object than the centre. Consequently, with an ordinary eyepiece and a high powered objective, it is impossible to focus the centre and edges of the field at the same time. To eliminate this difficulty some eyepieces are made to compensate for this aberration. Those manufactured by Zeiss are designated by the title "K." These give an apparently flat field with high-powered objectives and make the examination of colloidal sols easy and comfortable.

The Magnification. — The power obtained by using a K 20 x eyepiece in conjunction with a 90 or 1/12th objective of good quality is 1800, and this has been found ample for practical purposes. Extending the tube-length will give a slight increase in magnification, but this is inadvisable as the various lenses are adjusted for a definite length of tube.

The Stand. — This is a matter of choice for the individual. Most workers have their own particular fancies. Practically any good stand with accurate focussing and an adjustable substage will suffice. A micrometer scale on the fine adjustment is useful as it helps the operator to estimate the depth or thickness of his preparation. This is a helpful adjunct and allows more accurate comparison of the number of particles in solution. For work with blood serum it is advisable to aim at getting the

same thickness of preparation in every specimen. If there is it great variation it may tend to upset the accurate estimation of particle numbers in solution.

Brownian Movement. — In order that the serious worker may be thoroughly familiar with the appearance and behaviour of colloidal particles and their typical Brownian movement it will be necessary to study this phenomenon in a practical manner. Their rapid oscillatory movement was first discovered in 1827 by Dr John Brown, a botanist. The peculiar type of movement is now assumed to be caused by the impact on the suspended particles of the moving electrons of the atoms in solution. Owing to the small size of these particles there is a mathematical probability that one side of a particle will be subject to more impacts than its other side at any particular moment. As the size of the particle becomes larger, it necessarily follows that the probability of its being hit more symmetrically becomes greater. That is one reason why small particles in sols often have greater activity of movement than the larger ones. There is also probably some measure of influence by the number of moving electrons in the suspension fluid. An acid solution being deficient in moving electrons consequently will have a tendency to a more sluggish movement of the particles. An alkaline solution should, on the other hand, have a more vigorous movement of the particles along the same line of reasoning. At the same time it must be remembered that in an acid solution there is its tendency to reduce the size of the suspended particles, and an alkaline solution would tend to increase their size. In practice it may be very difficult to tell by the observation of movement alone which influence is the predominant one.

It is recommended that the worker unfamiliar with colloidal work should examine all the material he possibly can with the ultra-microscope, as the results of this type of observation are amazingly interesting.

Milk is partly suspensoid and partly colloidal. The large globule of yellow fat is too large to come into the colloidal range. The smaller ones show a considerable amount of movement. In milk it is possible to see many types of movement from slow to vigorous, and therefore it forms a convenient and useful medium with which the beginner can practise preliminary manipulation of his microscope.

A large number of medicinal preparations in solution, especially those prepared by British Colloids Ltd., display diverse characteristics and various types of Brownian movement. These sols, particularly the metallic ones, have large refractive particles and frequently display beautiful colours. The preparations keep almost indefinitely, and, being convenient to use, form a useful training-ground for the ultra-microscopist as a preliminary to his examination of blood sera. They are a never-failing source of interest and amazement to one's friends and colleagues. They intrigue even the most sceptical, and demonstrate that this typical agitation of minute particles is not necessarily life in an elemental form. A bottle of one or more sols on the bench is invaluable for setting and adjusting the optical arrangement of the dark-ground substage condenser, which is very tricky unless one has a known picture on which to work. With a drop of colloidal silver one can always set up the microscope and adjust, knowing full well that there is a bright picture to be seen. From that it is a simple matter to readjust the tube for a blood film, which, owing to the weak refractive powers of the protein particles, can sometimes be exceedingly difficult to manipulate unless the substage and lighting adjustments are in correct relationship.

Collosal Argentum, or silver, was one of the first preparations of the group named "Collosal" (trade mark of British Colloids Ltd.). It is a mild but powerful germicide, which is used in eye work in addition to its other internal and external uses. It contains one part of protected colloidal silver

in two thousand parts of solution. Under the ultra-microscope it presents a most impressive sight — myriads of bright blue-green particles, each darting backwards and forwards with apparently never-ceasing vigour. Occasionally a lighter particle, slightly larger, and a few orange-brown particles can be seen. This picture is one of amazing loveliness, and would convince anyone who states that colours do not exist in colloidal particles that such is not the case. Words really fail to describe the picture accurately. The colloidal silver of Messrs Evans, Sons, Lescher & Webb is similar in appearance but displays a much more definite shade of blue.

Collosal Aurum, or gold, is chiefly of use for diagnostic purposes in Lange's test of the cerebro-spinal fluid. It has many other uses in therapeutics, but writers do not seem to have much concurrence of opinion on its use, although it is of undoubted value in certain conditions. The picture presented by this sol is not so much one of colour as varying size. The particles are bright yellowish white of varying sizes and shapes. It is difficult to get a slide that does not show a large number of small particles precipitated almost in a continuous sheet of the glass. The remaining particles in solution are small and large with moderate movement. A number of particles tend to clump together and exhibit the characteristics of a very hydrated blood serum, while the precipitation in sheets on the glass is suggestive of dehydration. Probably the gold, which is at the bottom of the list of electro-motive series (Chapter 111), tends to form more unstable or erratic grouping when in combination as a sol. Around some of the larger condensed particles can be seen what McDonagh calls an envelope. This is a zone of electrionic activity, which is probably akin to if not similar to the external membrane which can be seen in stained specimens of meningococcus.

Collosal Calcium consists of a solution of 0.85 per cent. calcium oleate, and in colloidal form is probably more easily

assimilated than in other forms. The picture presented is totally different from the previous ones. The particles are very small, but vary somewhat in size. Instead of being clear cut particles they exhibit a diffuse effect rather like the halation of an over-exposed highlight in a photograph. The result is that the background does not appear black as in other sols but somewhat opaque. This fogged appearance can be seen in some specimens of blood and seems very definitely to be a characteristic of calcium in colloidal solution. No non-calcium sol that the author has examined exhibits this peculiar whitish light-diffusion effect.

Occasionally in calcium preparations peculiar effects can be noticed, and these are undoubtedly due to crystallization of calcium salts. These crystals frequently take shapes similar to organic forms, and probably are the basis on which a few men have based their claims of producing living or organic matter from inert substances. There is a wealth of possibilities, for experimentalists who wish a field of research, in calcium and possibly carbon in a colloidal state. It may here be intimated that the above suggestions are far-fetched, but space will not permit more than an assertion that the author has actually seen hundreds of photomicrographs and a number of specimens of these forms which have been claimed to be the reincarnation of animal and plant life from protoplasm isolated from the mineral kingdom.

Collosal Cuprum contains one part of copper in 2000 of solution, and is used as a palliative in many malignant conditions. As a catalyst it probably has a useful effect in activating the iron administered in advanced and debilitated conditions. As with gold, the smaller particles have a tendency to precipitate on the glass. The particles still moving are for the most part reddish white, with a number of larger particles which exhibit a fine luminous copper-red colour like that of the setting sun in summer.

The examination of a number of well-known drugs and solutions in common use, with an ultra-microscope, rather tends to give one the firm belief that a far greater number of substances exist in the colloidal state than is generally believed. For this reason it is felt that this peculiar range of chemical and physical behaviour of substances has been somewhat neglected by research workers. The underlying principles of colloidal chemistry permeate our very lives to such an extent that, to my mind, a true knowledge of medicine is impossible unless based upon a keen understanding of colloidal behaviour.

The Chemical Garden is an interesting colloidal phenomenon. Before leaving the consideration of Brownian movement to pass on to its application to blood sera, it would be well for the reader to perform a simple experiment and examine the results for himself. The peculiar chemio-physical effect of the well known chemical garden will well reward the student who examines it. The chemical garden is made in a solution of sodium silicate about 20 per cent. strength. Warm or hot water is added to the thick silaceous gel, stirred well, and allowed to settle and cool in a covered jar. A few crystals of metals such as copper sulphate, magnesium sulphate, or cobalt nitrate, each about the the size of a pea, are dropped gently into the solution and allowed to remain undisturbed for twenty-four hours or more. Weird, fantastic designs, like trees in a ghostly wood, begin to form and grow in many odd shapes and designs. With a dip-rod a small piece of the formation is gently removed from one of the growths (say copper sulphate), and placed on a slide, covered with a slip, and examined under the ultra-microscope. If the small silaceous crystal is found and focused under a low power (say 1/16th), and then the edge of it focused under the 1/12th objective, peculiar colloidal phenomena can be observed. Near the edge of the crystalloid mass can be seen myriads of agglutinating tiny particles all oscillating and trying to overcome the electronic repulsion to settle on the crystal .

At length they manage to approximate and stick to the large mass, where they gradually adhere and are eventually built up into the crystalloid structure, which can be seen under a low power. The intermediate zone between agglutination and crystallization can be clearly differentiated in its various stages. In this picture can be seen a transmission from agglutination to crystal; probably this is similar in process to the transition of dehydrated particles into hydrated ones. McDonagh (1936) calls agglutination, hydration. This brings us back to the principles of relativity, which were all too briefly indicated in a pervious chapter. It shows that at infinity there seems to be a tendency for extremes to meet as though comprising segments of a circle. As we go around the circle, we suddenly come to a point where positive may become negative. This teaches us that, thinking in terms of the cosmic mind, we must not be influenced by set ideas which have been transmitted down from our forefathers for generations, and which are therefore finite. In electrionic medicine our thoughts must be broader and unbiased. They must be, in other words, infinite and relative.

Other "trees" from our chemical garden present different pictures, but all are equally interesting, and will well repay further examination with varying powers. The different activities to be seen near other forms may probably be accounted for by a different type or degree of electrionic activity between the colloidal sodium silicate particles and the crystal of the metallic salt.

CHAPTER XI

SERUM COLLOIDS

Collection of Serum.— In order TO examine the blood serum of patients from the colloidal aspect it is necessary to collect about 1 c.c. in a special tube and allow it to clot so that the clear liquid may he examined free from the red and white blood corpuscles. The tubes adapted for this purpose are easily made with a suitable glass tubing and an ordinary gas blowpipe usually available in any dental workshop.

In order to eliminate breakages and to minimise any electrionic change in the serum, it is essential to use a good quality hard-glass tube such as "Monax," of about 5/16th-inch external diameter. This can be obtained for a few shillings per pound, which is sufficient to make a number of pipettes. The tubing should be first scratched with a file and broken sharply into lengths of about 6 inches. These short tubes are then boiled in a solution of soap-flakes and water. They are cooled and rinsed in running water and then dried in an oven, care being taken to have each tube perfectly clean and free from moisture before blowing. Each tube is rotated with its centre portion in a fair-sized blowpipe flame, and when this part is soft and pliable it is pulled out to arm's length. This results in two tubes about 2 inches long connected by a length of fine capillary tube. When cool, each tube is broken, leaving about 2 inches of capillary tube attached to each tube. The capillary tube is broken up into lengths of about 5 inches and carefully preserved. Each tube is now sealed by rotating the thick end in a smaller flame until the bottom becomes completely occluded by a bubble of glass.

When cool the capillary end is sealed. This is in turn allowed to cool. A small flame is now played on one side of the main tube about half an inch from the part at which the capillary end begins. The glass when soft blows out owing to expansion of air within, and shortly punctures. The object of this puncture will be clear in a moment or two.

Just before using, the sealed end is broken off the capillary tube. One of the patient's finger-tips is chosen which is comparatively soft, either the little or third finger on the left hand usually being the easiest. It is obvious that puncturing a tough skin is more difficult and painful than a soft one. The tip of the finger is wiped with surgical spirit and allowed to dry. The blood is now squeezed to the end of the finger by the operator's first finger and thumb. A short quick jab with a sterilised triangular needle will make a suitable perforation with comparatively little discomfort. Naturally a little practice is needed to get just that right control of force required to penetrate the skin and not go too deeply.

The needles used are the ordinary straight triangular abdominal needles and can be obtained about 3 inches long. They are also made nearly double this length, and these may be found by some workers to be more convenient in manipulation. They can be sterilised by keeping in spirit when not in use.

A small globule of blood now appears on the finger-tip, and by a process of "milking" the finger the tube can be readily filled. Immediately the capillary end of the tube is touched to the drop of blood it runs down the tube, which should now be held slightly downwards so that the blood may run to the sealed end after it has completed its course of the capillary. The tube should be carefully held so that the little perforation is on the opposite side of the tube to and above the stream of blood, in order that the air may escape upwards. If the hole is accidentally occluded by a film of blood the tube will not fill owing to backwards pressure of air, and the hole must be

cleared before proceeding.

It is advisable to obtain at least one-quarter to one-half inch of blood in the tube; a smaller quantity may have a slight electronic reaction with the glass and air, possibly giving a wrong and misleading impression on detailed examination. Evaporation has also to be considered, but if there is a fair amount of blood present the effect is not noticeable. Bloods can be kept in almost their original condition (after clotting) if the two tiny orifices are covered by plugs of plasticine so as to render the tube air-tight. The tube is now placed upright in a hole drilled to the correct size in a piece of wood. This stand can be made of a piece of 2" x 2" hardwood 6" or 8" long and drilled every inch with a suitable hole about 1" deep. A number of tubes can thus be kept conveniently until required.

In order not to mix the various specimens, some form of marking is necessary to identify them. A small piece of adhesive tape can be stuck on and marked. More conveniently the glass itself can be marked with a special pencil. These are handier, especially for marking the micro-slides, if it is required to re-examine them at a later time. The pencils are manufactured by George Rowney & Co and A. Gallenkamp Co. Ltd. The former are slightly softer and used for glass or china marking only. The latter are harder and for china marking only. Either kind can be used, but they will not take easily over even a thin film of grease, such as a finger-mark.

When it is required to examine a serum the capillary tube is broken off so as to enlarge the orifice. A length of capillary previously obtained when blowing the tubes is now inserted and dipped into the serum, taking care not to get any red cells; the serum flows up the tube and can be withdrawn and blown out on to a clean slide of the required thickness. A clean cover-slip is placed on the table and the slide inverted over it, so as to pick up the slip by attraction of the globule of liquid. This applies the slip more gently than could be done by dropping it

in place, and consequently eliminates a tendency to occlude air bubbles which are disastrous to the examination of a slide owing to light diffraction at their surfaces. The slide is then turned over and placed on a flat steady surface with the cover-slip on top. It is then pressed home with a thin filter-paper folded double to absorb any excess of expressed liquid. Blotting-paper is useless for this purpose owing to the amount of small bits of debris left behind. A drop of cedar oil is now placed on the bottom of slide and another drop on the cover-slip directly on top, and the whole is placed gently on the stage of the microscope, taking care to avoid bubbles between the dark-ground condenser (which also must receive a drop of oil) and the slide. The objective is gently lowered into position until a rough focus is obtained; the fine adjustments having been made, one can then examine the specimen in the light of its colloidal construction.

To misquote a popular quotation: "There are more things in human serum than are dreamt of in medical nightmares." The myriads of phenomena and the scarcity of references in scientific literature to this method of examination of blood sera render necessary a description of some of the peculiar sights to be observed. Although the words of the English language are hopelessly inadequate to describe fully what may be seen with the ultra-microscope, it is hoped that the following brief sketch may assist the earnest research worker.

Owing to the fact that biologists have for many years used almost exclusively stained specimens for examination, dark-ground phenomena have been almost neglected except for the study of living spirochætes. Scientific literature contains little if any authoritative information on this subject, and consequently it is felt that one of the most valuable and useful allies of medicine has not been enlisted in the search for health. The ideas expressed in this chapter are the outcome of many hours research and may appear to contain some revolutionary

suggestions. The reader is earnestly requested not to scorn them, but to apply the ideas in practice and evolve more complete knowledge along these lines. For the sake of convenience in referring to various details the different phenomena are sectioned under their respective headings.

Protein Particle Size.- It has been pointed out previously that the molecular weight of protein is about 34,500. The water molecule size is 0.7×10^{-8} mm. A molecule 10,000 times this size would be about 0.7×10^{-4} , or 0.7μ . If reference is now made to fig. 12 it will be seen that this is almost half-way in the range of size of the colloidal state and almost within the range of microscopic resolvability. Which argument is partly at variance with statements to the effect that particles can only be rendered visible as points for scattering of light rays, as in all probability some of them at least can be seen. As this size is about the average molecular weight given for protein, it may be assumed that this is normal for healthy protein. It has previously been stated that at one point of size the ratio of physical surface to chemical mass would be at the optimum point for maximum potential interchange of energy. As the protein particles in the blood plasma can be regarded as conveyors of electronic and atomic energy, it should be obvious that in health this degree of subdivision would be necessary. The energy is relatively loosely bound and can be passed on to cells and other parts requiring same, which would, therefore, by comparison, be relatively positively charged. From these remarks it will be obvious that some proportion of the protein particles in the healthy plasma should be clearly seen and all be approximately the same size. Furthermore, because the healthy blood is well buffered and slightly alkaline, it should be full of actively moving electrons which by impact would agitate the particles in vigorous and comparatively equal jerks in various directions.

Schafer (1920) gives the diameter of the red blood cell to be

about 6.7μ . It would be reasonable to expect the protein particle in normal blood to be about one-thousandth the size of the red blood cell. Allowing for slight inaccuracies in calculations, as the protein constituents and electronic condensations are almost impossible to ascertain accurately, these figures show a surprising degree of correspondence with observed fact. Actually, the particle diameters appear to vary from about a hundredth to about a fifth the diameter of the average red cells. Furthermore, it must not be forgotten that the actual size variation is relative to the cube of the diameter. This, therefore, brings further evidence to bear on the statement just made—that the protein particle has a size which is frequently within the limits of microscopic resolvability.

Protein Particles show a variation in size which is brought about by countless factors. They can, nevertheless, only vary in two dimensions. Either they increase in size or diminish. Any factor which tends to disturb the electronic and atomic balances of the suspension medium or the suspended micellæ will tend to have an appreciable effect on the particle size. Whether the increase in number of particles in dehydrated sols is due to an actual breaking-up of the existing particles, or whether it increases the size of the amicrionic particles previously invisible in order to compensate in some measure for altered conditions, is very difficult to determine. The reasonable attitude is to assume both possibilities. The normal healthy serum presents to view myriads of particles merrily dancing about, and in spite of the terrific agitation there are few, if any, collisions to be seen between individual particles. Each one carrying a powerful negative charge, they probably exert a strong repulsive force towards each other. The field is full of light due to reflection from the calcium atoms which are adsorbed lightly to the outer surfaces of the particle, This gives a general halation effect to the picture and almost suggestive of an amicrionic haze, which can sometimes be seen in a slightly

dehydrated blood.

If a freshly obtained drop of blood is examined there will be seen a number of blood corpuscles with a clear-cut outline and a few white cells with irregular outlines.

Dehydrated Particles.—If energy is removed from the plasma, resulting in an excess of acid (i.e. deficiency of electrons), the tendency of the particle is to break up and become smaller. At the same time a number of amicroionic nuclei probably obtain an increased power to adsorb the thrown-off constituents, and consequently there may be an increase in the number of particles to be seen. The picture observed depends upon the degree of dehydration present at the time of collecting the plasma. Owing to the fact that negative charges are lost they become relatively positively charged, and there is a gradually increasing tendency for them to aggregate in clumps or precipitate in sheets on the surface of the slide. The degree of intensity of the agglutination naturally depends upon the attraction of the positively charged particles. Dehydrated particles must be differentiated from dispersed particles, as these, being the result of breaking-up hydrated particles, carry a relatively negative charge; they do not, therefore, tend to agglutinate or precipitate easily on the glass, unless of course the dispersing agent has been used in too strong a concentration.

Hydrated Particles.—On the other hand, particles of different sizes will have different forces of attraction. The maximum power of repulsion is exerted only when the particles are approximately the same size and provided they do not come too close to each other. If one of the particles has an increased size its internal chemical structure may be such that it will tend to attract and adsorb other particles of a weaker power than its own. The process is similar in many ways to the attraction of iron filings by a magnet. Should the electronic state of the serum be such as to permit this adsorptive process to come

about there is a decrease in the number of particles to be seen with all increase in the size of those remaining. Frequently the size of the particles in hydrated bloods varies from very small to very large particles on the verge of precipitation.

Possible Errors of Diagnosis may arise in advanced cases. In dehydration there may be a large number of agglutinated particles deposited in parts of the body, and therefore not visible when the specimen is examined. Likewise, in hydrated blood, a number of the larger particles may be precipitated in various parts of the body and consequently not be seen in the preparation. Long-standing upsets might also tend to reduce the number of smaller particles by filtration through the kidneys.

Reversibility being a prominent characteristic of blood plasma, it is obvious that changes may occur in both directions. Moreover, they may occur simultaneously. This fact makes it extremely difficult to diagnose the condition accurately and renders it imperative to utilise other tests in addition to the ultra-microscope. Especially is this so in cases of chronic disease of many years standing.

Red Blood Corpuscles in Hydration present numerous changes of appearance. In hydrated bloods the corpuscle appears bloated and swollen and often increases by about 50 per cent of its normal size, and it becomes more ovoid and less discus-like. When fully engorged it is not flexible and cannot bend. Eventually, if hydration had progressed sufficiently, there would be a bursting of the envelope and a freeing of the internal constituents. This swelling of the envelope is due to osmosis. Owing to the adsorption of solid matter by the hydrated particles the suspension medium becomes more like water in character and the constituents inside the envelope adsorb water through the surface in an attempt to equalise the resultant tension.

Red Blood Corpuscles in Dehydration are carrying a relatively negative charge compared with the electron-deprived

particles and so tend to attract them in the early stages. The small particles then appear to adhere to the envelope and later be absorbed into its structure. Generally osmosis would tend to rob the corpuscle of water and add to the crenated effect of the envelope. Eventually the crenations render the red cell very similar in size and shape to the white cell, which fact rather tends to suggest the possibility that there is a more intimate connection between these two cells than has been previously credited. In the anæmias the red cells are often diminished and the whites increased; and as these cases usually are those of long-standing and powerful dehydration the possibility is interesting.

If watched at intervals for several days under the ultramicroscope these crenations elongate and evolve a mobile filament-like prolongation which projects about 1μ . A small knob forms on the end and the thread-like growth eventually separates, and moves away, showing two knobs, one at each extreme. These are further described under the heading of pseudo-spirochætes. Reference to this peculiar behaviour is difficult to find. The only reference that could be found which bears a resemblance is Kræmer's reference to dibenzoyl cystine gel. The dibenzoyl cystine is dissolved in hot alcohol, and water added to make a 2 per cent. solution. When examined under the ultramicroscope "long thin fibres entangled together made up the visible gel structure. The viscosity of the medium between the fibres appeared to be practically unchanged. The fibres themselves were also in motion. Short ones twist and turn about like flexible rods. Longer ones, fixed at both ends, were like cords in a breeze."

Further researches with dibenzoyl cystine might throw new light on the atomic structure of clotting or other phenomenon of a like nature. Directions for making will be found in Cohen (1926) and Gortner and Hoffman (1921).

Red Blood Corpuscles (Venous).—In contrast to the

brilliant appearance of the oxygen-carrying cell, the venous, or one carrying carboxy-hæmoglobin, appears to have a thin, less refractive outline, with a deep black interior. It appears as a rule to be smaller and less refractive than the arterial ones. Frequently small particles are attached to its margins. Crenations and growths do not seem to appear.

Red Cell Casts.—In some serums casts of red blood corpuscles can be seen. These are often found in blood, which have been subjected to a severe dehydration process, which weakens the envelope, and eventually breaks it, freeing the internal constituents, leaving a recognisable cast which can easily be identified.

Blood Platelets are about one-third the diameter of the reds and appear crenated, with an appearance somewhat similar to that of a tiny sea-urchin. They are not seen in clotted serum as they form part of the matrix upon which the clot forms. In fresh blood the crenations throw out long fibres, which do not move from side to side but unite with the thread from another white cell or particle, until the slide is literally covered with a tangled network of thin lines. Blood platelets are suggested by McDonagh (1933) to be hydrated particles. Schafer (1920) makes a similar suggestion when he puts forward the idea that platelets are formed from elemental particles of varying size, which are discrete in serum but immediately clump together when blood is withdrawn. They are amœboid in character and vary considerably in size and shape.

White Blood Cells vary greatly in shape and are almost impossible to identify individually in the unstained specimens. The giant cells are several times larger than the reds and look rather like a very big agglutination. Sometimes they can be seen with numerous tiny particles adhering, occasionally a nucleus can be seen composed of very refractile substance.

Pseudo-Spirochætes. _Under this heading are classed all the peculiar thread-like bodies which can be seen in the serum.

Pathologists are sometimes inclined to ignore these bodies or class them as artefacts. The most common shape is a rod-like form which may vary from 2μ to 15μ in length, sometimes it has a small knob at each end, frequently it waves as it moves. At times can be seen bodies like a short coiled spring, which dart about with alarming rapidity. Then these bodies take a shape rather like an elongated cell with two well-defined cilia at its extremities. In fact there is no end to these peculiar forms which are to be seen. For the most part they appear in dehydrated blood, although this cannot be taken as a rule. They are probably composed of threads of protein.

Micro-organisms.—Under the impression that there might be some connection between pseudo-spirochætes and the various micro-organisms, a number of broth cultures of the latter were examined under the ultra-microscope. Unfortunately no connection could be established. At the same time definite information was gained, and, as it may be a help to others in their researches, it is recorded.

Staphilococci appear as large wavy circles about 1μ or 3μ in diameter. This, size is somewhat greater than that quoted by Bigger (1936) - this may possibly be explained by the fact that the illumination of the ultra-microscope illuminates the outside of the envelope only, and consequently would tend to show the greatest possible size of the object. The outline is very distinct and the centre quite dark. They have some power of movement, the mechanics of which are not obvious. Occasionally they can be seen to turn over, when they seem to be shaped like small platelets.

Streptococci appear as long chains with a cross-section of about 1μ ; they appear to be sectioned in a manner somewhat similar to algæ. Some forms appear definitely motile.

Diphtheroids are slightly smaller than staphylococci, segmentation is irregular and not so definite. They take shapes which are very suggestive of Chinese letters.

Coliforms are sausage-like shapes about 1μ or 3μ in diameter. Sometimes they are mobile and appear to move by bending in the centre and jerk about with astonishing speeds.

Spirochaetes vary enormously in shape and in number of spirals. The pallidum has about nine spirals and moves very rapidly when fresh. It is a delicate fragile-looking object. The mouth forms are much fatter and sturdier. They usually have fewer spirals and vary enormously in characteristics.

The details recorded above are not meant to be in any way complete. As it is impossible for the student to gain his information by a word picture alone, much practical work will be necessary. It is hoped that the foregoing outlines will facilitate his researches and enable him to gain more information about a subject which has such immense possibilities.

PART III

ELECTRONIC MEDICINE

CHAPTER XII

CLINICAL COMPARISONS

From what has been written, the reader will probably have formed the idea that there are two possible forces at work on the particles. Briefly, the process of disintegration and the process of condensation are continuously yet intermittently opposing one another. The healthy body is one in which these two forces are at work in a constantly balanced mechanism of interchange. Owing to a number of reasons, there are occasions when this balance becomes disturbed, with resultant physiological effects which will be dealt with in due course. For the present it is necessary to picture the condition in the normal individual so that we can see later the manner in which variations from this happy state may occur.

The Normal Blood Picture

The blood picture of perfect health is unfortunately only too rare, but nevertheless it must be visualised clearly, because the aim of all treatment will be of necessity to attempt to bring about a reversion to normal as completely and as quickly as possible.

1. The blood when first drawn appears bright red in colour and coagulates quickly.

2. The particles are present in large numbers, and all appear about the same size with a slight appearance of haze or halation on each particle when viewed under the intense illumination of the ultra-microscope. Their Brownian movement should be very active, the particles bouncing, about in all directions with no trace of a collision or tendency to dance about each other. There should be no agglutination, precipitated particles, individually or in sheets, and no giant particles.

3. The percentage of sugar would be from 0.131 to 0.081

per cent., amino-nitrogen and non-protein nitrogen should be present in normal quantities. But if the particles have been corrected for previous dehydration these percentages may for a time be slightly-lower owing to the adsorption thereof by the particles.

4. The viscosity is slightly raised, a healthy blood being viscous but not viscid. The viscosity tends to be lower if blood is dehydrated. It also tends to be lower just prior to coagulation, after which it becomes raised very considerably as the clotting progresses.

5. The refractive index should be just under 1.3500.

6. The suspension stability is from 1.5 to 2 cm. in 10 cm. The movement of electrons in the liquid is sufficient to keep the relatively small particles in active movement, thereby almost completely counteracting the attraction of gravity on the red cells. The increased suspension stability would give a lower figure to the reading as this is measured by the drop of the red cells after sedimentation.

7. In all, the clinical aspect is good health, the patient works hard, sleeps well. Humour and appetite are good and the little annoying things of life seem almost too trivial to be noticed. The skin is moist but not wet. The teeth are good, white, and hard, and can be drilled if necessary without pain even if the burr is allowed to run hot. There is little new formation of caries and the gingival margins adhere closely and firmly to the necks of the teeth. The gums can be brushed vigorously with a hard unbleached bristle without any trace of bleeding.

In short. if one can imagine all the promises of the patent medicine vendors applied to any particular individual, the result would form a good picture of the normal, to wit, the picture of Health.

Disintegration

Under modern conditions of living, the force of disintegration seems to be one of considerable importance.

The stellar bodies are radiating energy and losing mass, the earthly objects around us are constantly tending to break up and lose their original form. In a chemical mechanism such as the human body, in which energy is continuously being assimilated and utilised for numerous functions, one would expect to find a strong tendency to this process of breaking-up. As the breaking-up or liberation of energy in the serum frequently takes the form of a radiation of electrionic activity, the obvious result would be to find an increasing residual quantity of positively charged atoms, *i.e.* acid ions.

To neutralise these effects a considerable intake of alkaline metallic salts (those towards the top left corner of the periodic table, fig. 4) are required. These buffer salts have a strong negative charge and a comparatively weak positive charge, or alternatively, they can be combined so that the resultant acid compounds are easily removed from the body. To-day, unfortunately, our artificial modes of living increase the tendency to form acids, and also retard the processes of elimination. As absorption of foodstuffs through the bowel is a mixture of dialysis and osmosis, it is necessary to have a higher concentration of salts in the intestine than in the bloodstream. If the concentration is lowered in the bowel through slow movement of stools, or through insufficient intake of electron-charged alkalis, the result in the body is a condition of acidosis in the electrionic sense. This means that the colloidal particles become deficient in electrionic activity, and will tend therefore either to break down other constituents of the body or to rob one another. As we have seen from our colloidal studies, the resultant effect is to break up the colloidal phase and send it into true solution, or if the reaction is sudden the positive charges are such that they tend to clump together and agglutinate (*i.e.* form a gel). This is somewhat similar to the phenomenon of coagulation in certain respects. In a blood, therefore, which was subjected to the forces of disintegration

we would expect to find the following characteristics:

1. The blood when drawn would be dark red and coagulation would be retarded owing to the serum being more of a solution than a colloid. In early or sudden cases it might tend to accelerate the clotting time.

2. The particles present would be diminished in number and the Brownian movement would be very slow, due, of course, to the deficiency of moving electrons in the more acid solution. If the disintegrating force was a positive ion, very few particles would be found, and these would have a strong tendency to dance about each other and eventually to agglutinate. If, on the other hand, the dehydrator was a negatively charged ion or particle, the number of particles might tend to increase owing to the ion or particle acting as a nucleus. If the dehydration was suddenly produced, as in acute infections, there would be myriads of particles all about the same size, very small and with a great tendency to gel or to precipitate out in sheets on the slides. At this stage it is important to differentiate between particles undergoing the processes of gelation or agglutination and those undergoing dispersion. The former are generally sluggish, with a tendency to clump or adhere to glass; the latter are more active, and have little or no tendency to clump or adhere to the glass.

In many cases the tendency to hydrate or condense is very intimately mingled with the tendency to dehydration or disintegration. Especially true is this in long-standing, chronic cases. For which reason it will be well to mention one or two complications. In advanced cases of gelato-hydration many particles may have lost their individual characteristics and have left the peripheral circulation to precipitate in some part of the arterial or venous system. If gelation prevails, agglutinated particles are visible in sizes and quantities varying with the severity of the condition; there are also some particles precipitated. If hydration prevails there can be seen giant and

small clumps, both moving and precipitated.

3. The percentage of urea, uric acid, sugar and amino-nitrogen, calcium, and other salts normally adsorbed to the particle would tend to be increased. The depth of dehydration can be measured clinically by the increase in various protein constituents, the increases denoting the layers affected. If dehydration had progressed for some time there might be a decrease in the amount of salts and other constituents owing to the removal of some from the blood by osmotic action through the bowel wall, kidney, and skin. When this happens there is a tendency to have an admixture of hydration in the picture as well.

4. The viscosity would be diminished owing to the loss of colloidal character. If hydration were marked it might compensate for this change and even give a result on the opposite side of the scale.

5. The refractive index would be diminished, especially if particles had been sent into true solution. The more homogenous the solution the lower would be the figure recorded.

6. The suspension stability would tend to be reduced, although it might be unaltered in cases of marked gelato-hydration.

7. The clinical aspect is ill health, and basal metabolism is increased so long as there is no marked hydration.

The type of patient who fits this picture is the sympathetic dominant; they are usually fair-haired, red complexioned, energetic type. They are usually susceptible to colds, influenza, and acute infectious generally. The dental cases often present with a sudden flare-up of toothache or swollen face. They have a tendency to sweat profusely, frequently the clothes under the armpits are saturated, and often they have an aroma which renders the use of deodorants imperative. In advanced cases the gums are usually brilliant red, especially towards the gum

margins, sometimes there is hypertrophy and a Vincent's infection. The saliva is thick and viscous, sometimes scanty in amount, and has a pH of low value, frequently 6 or below. There is usually a soft sludge or film on the teeth, and soft tartar has a tendency to form all over the inner surfaces of the teeth especially in the lower jaw and outside the upper molars.

In early cases these patients sometimes have pale anæmic gums and buccal folds, and even when the gingivæ are red the rest of the gum may be pale. Most of these persons have definite evidence of gingivitis, and often there is a striping back of the gums over the roots of the teeth. There is usually a good flora of spirochætes and fusiform bacilli to be found in the mouth. Many adolescents of this type have a great tendency to pimples and spots on face, neck, chest, and back. The menses in females are usually prolonged and may have a tendency to be profuse. In some cases they occur at more frequent intervals than should normally be the case. Females becoming pregnant when this sort of picture is present frequently give birth to a girl, and are liable to toxæmias of pregnancy such as morning sickness and other well known symptoms. The teeth are yellow and soft, decay is usually rampant, and even carefully prepared fillings do not last. Amalgam fillings show small breaks at enamel junction, silicates will dissolve away or discolour in a very short. There is usually a tendency to constipation.

When performing extractions under local anæsthetic the patients may have a tendency to syncope, owing to the action of nervous tension combined with the administration of adrenalin causing agglutination in the portal system.

Such are the acidotics, subdivide and classify them how one will. These err in physical characteristics on the path of a defect or deficiency of electrons and electron-carrying atoms, and they show these indications very clearly to those who have an eye to see.

Condensation

We have seen how the helium atom might be built up from four hydrogen atoms. In some similar but not quite the same manner the protein particles may become bigger, and owing to an increased potency in the nucleus are able to adsorb more than their just allowance of constituents. This process of condensation increases the size of the particle, and is known as hydration. It is interesting to speculate in this connection, along the lines of the bitter controversy between Bastian and Lister last century, regarding the spontaneous generation of micro-organisms in urine. It is probable, in fact more than probable, that there is some intimate connection between a hydrated particle and a micro-organism. McDonagh (1936) does not quite suggest this, but he does describe the different phases through which micro-organisms pass as due to the influence of dehydration and hydration.

Hydration if well marked is an almost certain sign of chronic disease; in fact, hydration may foretell the advent of this type of upset years before the patient succumbs. The blood picture is as follow.:-

1. The blood when drawn is dark blue, rather like venous blood. Clotting time is not necessarily accelerated. In fact if hydration has progressed to some degree, it may be decreased. The coagulum quickly differentiates and is comparatively small. The serum remaining is pale or white owing to the adsorption of salts and pigments by the particles.

2. The particles are increased in size and decreased in number. Owing to this former circumstance they may not readily react to electron movement, and therefore appear sluggish. They are bright and refractile and tend to precipitate owing to the action of gravity. When slightly out of focus some of these refractile particles show a series of vibrating spectrum rings. The apparent vibration is probably caused by a beat produced between the electronic vibration and the atomic

vibrations of the filament in the illuminant.

3. The percentage of urea, sugar, amino-nitrogen, non-protein nitrogen, and other salts would be reduced owing to adsorption. The viscosity would be raised at first and later would be lowered owing to the removal of colloid structures through precipitation.

4. The refractive index would be increased, owing to the formation of globulin in contradistinction to albumin; the reading would be 1.3500 or greater, due of course to the differentiation of condensation areas of solids and a comparatively more water-like suspension medium.

5. The suspension stability is as a rule unaltered, unless in extreme cases where the size of the particle would facilitate the action of gravity in allowing the red cells to settle.

6. The clinical aspects of these cases is poor. Patients tend to be irritable and sleep poorly. Power to concentrate is lost, interest in life becomes progressively less. Basal metabolism tends to be somewhat diminished.

The type of patient who fits this picture is the parasympathetic dominant; they are usually dark-haired, thin, and pale or sallow-complexioned. There is a tendency to catarrh of all mucous membranes. Often this class are extremely neurotic and many are very irritable. They are not so easily susceptible to colds, influenza, and other acute infections, but often exhibit symptoms of chronic or allergic reactions. The dental cases usually present with a loose tooth or nasty taste in the mouth in the mornings. The gums are purplish and frequently have a rolled appearance about the gingival margins. often with deep pocketing. These are the true pyorrhœas. The saliva is thin and plentiful, and usually has a high pH, perhaps well over the 7. The teeth are strong and often caries-free, and hard dark tartar will lodge under the cervical border and does not as a rule select any particular tooth for its appearance. The bacteria present are coliform, streptococci, and numerous other

varieties. with occasionally Vincent's spirochætes.

The menses in females tend to be late rather than early, and pain is frequent at the commencement owing to free clotting in the uterus, which produces slight spasms, similar to those of childbirth but of smaller calibre. Females of this type becoming pregnant usually give birth to a boy at the first confinement, and are often free from toxæmia and other disturbances of pregnancy. In fact, some cases of hydration are improved physically to a very great extent; this is owing to the dehydration brought about by the growth of the fœtus correcting the condition already present.

The teeth are hard and resistant to decay, the roots have a tendency to fur and become exostosed, on occasions necessitating surgical removal. Fillings, even when carelessly inserted, seem to last indefinitely. Silicates may discolour but do not wash away.

Such then are the typical alkalines, and from this description the reader must learn to classify his types, so that he can see, on a close examination of the patient, the sort of upset with which he has to deal. Clinical diagnosis is of first importance, the biological tests should be used as aids and not be relied upon completely. The physician who depends entirely upon his text-book will meet many cases which puzzle him, but the physician who uses his ability for clinical deduction will build up a reputation for himself.

The definite cases are comparatively easy to treat, the mixed cases are not so simple. One has first to ascertain which feature is the predominating influence and correct its ravages. When the troubles or symptoms have abated, the attempt to correct the other irregularity can then be undertaken with some hope of success. By estimating the electrionic upsets, and correcting these as a pre-operative measure, dentistry and medicine would banish difficulties in anæsthetic cases and render after-pain and surgical shock a thing of the past.

Clinical Examination

Bearing in mind the blood pictures just described, together with the clinical symptoms of each, there should be very little difficulty in differentiating between the various types of cases in the average dental practice. The great majority of patients presenting for dental treatment fall into the class of dehydration. The normal picture is comparatively rare. In the author's experience it is almost so rare as to be an anomaly to find a perfect mouth in an adult. The majority of patients require fillings and gum treatment, which latter is all too frequently ignored, especially in the early stages. At the first meeting of a new patient, he or she should be sized up from a general clinical point of view. Usually it is easy to classify them as either dehydrated or hydrated after a little experience in observation.

Then examine the mouth as a whole. Note the ravages of dental disease. Are the teeth soft and decaying, or are they hard and white? This signpost obvious and needs but little expert knowledge. Next a careful study of the gingivæ and buccal folds. The colour conveys a wealth of information. Are they pale, red, or purple? Again the classification is clear. In conversation ascertain the number and quality of illnesses or operations the patient has had. The past history frequently tells the path which the colloidal system has travelled to reach its present state, and the more serious the illness the patient can retail, retail, the more likelihood there is of finding hydration present. Having examined the patient and noted all the points to be observed, the clinical classification can soon be decided.

Should the condition warrant it, the next step is to ascertain the pH of the saliva and obtain about 1 c.c. of blood for examination. The patient is then examined for routine dental conditions, which are recorded. Between the first and second appointment the blood can be examined and the line of treatment decided upon. The treatment is advised and the effect

watched during the numerous attendances needed for dental treatment, and can be altered or augmented if deemed necessary. After a time, as the operator becomes familiar with the conditions and treatment, he is bound to meet stubborn cases and patients who do not react quite as he expected. A special study of these has to be made, and it may be found necessary to undertake further physiological tests, in order to determine the precise degree of upset present, along the lines laid down in Chapter IX.

There is no experience so stimulating as to hear the favourable reports of patients undergoing treatment. Often, however, in patients who are slightly dehydrated there is no appreciable general effect noticed by the patient undergoing treatment, and these cases may almost be thought to be of negative value; but the dental physician may rest assured that he is helping to prevent serious illnesses in later years for patients of this type.

The patient who is off colour and who has had many tonics without avail will frequently appear miserable and despondent when first seen, and an amazing change is recorded after about a week's treatment. Some cases, however, will react slowly, especially those cases of severe hydration which may require many month's work and study before they can be returned to normal.

The only practical difficulty met with in dental medicine is that at present its value is not known to the general public, and the dental profession as a whole is somewhat sceptical. The question of fee is an important one and needs a large amount of consideration. As dentists realise that in dental medicine lies the real basis of prophylaxis, they will also learn to value it and put a just fee on its employment. The dentist who utilises the principles laid down in this volume will soon discover that he can control the ravages of dental disease more successfully than by mere fillings or gingivectomy. Therefore he must be

prepared, when proficient, to assess his skill on a treatment basis. When that day arrives the dentist will charge for his skill and advice, and will no longer sell materials in the form of amalgam or plates. Then, too, will dentistry become a real part of the medical profession.

It is in dentistry that we meet the early cases of upset which will eventually lead to serious consequences. *Prevention is better than cure.* But how many professional men to-day realise the full meaning of this phrase? Too often, indeed, a so-called cure is merely a palliative measure, and disease occurs later in perhaps a modified form. When dental medicine becomes recognised, as in fact it must be, we can dissociate ourselves with the relics of the blacksmith and barber days and stand before the world as a profession prepared and able to prevent disease. To that end the final chapters will be devoted to a description of certain common dental conditions and their treatment. Some of the therapeutic agents of value will be described. Finally there are recorded a number of case notes from which the reader should be enabled to obtain guidance in the carrying out of treatment in his own practice. The work so far done along these lines is at too limited and needs extension in many directions. One thing is clear, however, the principles recorded in this book show gratifying results in all cases to which they are applied, and that encourages one in the belief that soon these principles should be utilised more generally for the benefit of mankind.

CHAPTER XIII

ELECTRIONIC INFLUENCE OF DRUGS

Before, considering the influence of drugs along broad lines it will be well to consider briefly the process of elementary chemical combination from an electrionic standpoint. In combining, the basic radicals lose electrons and in so doing become relatively positively charged. On the other hand the acidic radicals gain electrons and therefore become relatively negatively charged. To clarify this further, let us take for example a few of the simpler chemical substances and consider them in the light of our present knowledge. The four radicles comprising water and common salt are H, OH, Na, and Cl. These resulting compounds are neutral. But when their radicals are combined in other forms there results hydrochloric acid and caustic alkali, which are two powerful substances of opposite characteristics. The exact reason for this result is not easily located, but a comparative study of the formulæ will be suggestive. (*Note.* A dot • denotes an electron lost and a tick ´ denotes an electron gained as a result of combination.)

(1) Hydrochloric acid	$H_2 \bullet Cl \prime$	Acid.
(3) Water	$H \bullet OH \prime$	Neutral.
(3) Sodium chloride	$Na \bullet Cl \prime$	Neutral´
(4) Sodium hydroxide	$Na \bullet OH \prime$	Alkali.

Consider further the carbonates of H and Na:

(5) Carbonic acid	$H \bullet H \bullet CO_3 \prime$	Acid.
(6) Sodium bicarbonate	$Na \bullet H \bullet CO_3 \prime$	Neutral.
(7) Sodium carbonate	$Na \bullet Na \bullet CO_3 \prime$	Alkali.

From the study of these few formulæ it is obvious that the passing along of an electron or so is not sufficient to change a compound into either acid or alkali, as this change has taken

place in all formulæ. We must seek, therefore, another and more helpful basis as a working hypothesis. To do this it will be necessary to refer back to the earlier chapters about the electronic conception of matter and radio-activity. The electron is generally held to be more or less synonymous with negative electricity, which is, after all, but a form of energy., In the last few years the belief is steadily growing that although the corpuscular theory of matter is very convenient to describe many of the observed chemico-physical properties of matter, it does not completely explain certain phenomena. In other words, we must realise that matter takes some form which has both corpuscular and wave forms.

The idea of waves instead of electrons so complicates the picture that a lengthy dissertation will be omitted. However, a brief outline to help our researches is necessary. To picture the electron as a wave may not be easy, but imagine a long piece of rope tied to a nail on a wall. The free end is held in the hand and moved up and down to cause a beat or wave in the rope. According to the vibration applied and length of rope, so a number of waves is set up. If the end of the rope is now held stationary the vibration keeps on for a time, and it will be noticed that certain loops of the rope have the maximum movement on the crest of the wave, whereas other parts where the two waves meet, merely turn about a point. The two ends of the rope have a similar relationship in that they do not move up and down with the wave crests. This experiment demonstrates what is known as a "stationary wave", an oscillation which does not travel through space. Now by a stretch of the imagination this picture of a stationary wave could be portrayed in the mind as on a circle with the waves travelling as before. A further expansion and we have a fairly good diagram of this movement in three dimensions as the surface of a sphere. Then you have some rough idea of the wave mechanics interpretation of a moving electron. This, too,

would explain why the shells or orbits of electrons must exist in very definite places; and, as a continuous wave motion could not be obtained with half waves, the visualisation becomes clearer.

Next, we have to rid ourselves of the idea of anything concrete or solid revolving in the orbit. In fact, we must visualise our wave as a definite vibration of energy potential. If this vibration of was always stationary no effect would be noticed, but, as it moves, various effects can be observed. Heat can lengthen the wave and expand the atom, cold has the reverse effect. When elements combine, energy or electrons move. Previously we have learnt of the loaning and borrowing of an electron. To get the correct mental angle on treatment we must advance a step further in our conception of matter. The previous thoughts of quanta, corpuscles, electricity, waves, must be modified slightly when we analyse drugs in their relation to treatment. For our purpose we must approach a conception which can most readily be summed up in the word "activity". The electron, picture it how you will, is definite activity, the value of which is as yet imperfectly understood.

However, having followed these pages so far, the reader should be able to that *this "activity" may be radiated in two directions - outwards or inwards*. With that thought as a basis, we can now refer back to the formulæ given at the beginning of our chapter with more expectation of assistance. The metals, speaking generally, are negatively charged; they are donors of electrons and tend to radiate activity from within outwards. The non-metals on the other hand tend to attract electrons; they are positively charged and radiate activity from without inwards. Here we must succumb to an interesting speculation, which entirely theoretical. The above suggestion carried to its logical end is that all elements may be radio-active.

Soddy (1932) in this connection suggests that "if any of the common elements were emitting α -rays with range and

velocity much less than those of the known radioactive elements, their periods would be so excessively long that, to ordinary tests they might not show detectable radio-activity at all. There is a certain amount of evidence in connection with the topic now to be discussed that this may actually occur”.

He then proceeds to give proofs of this effect. Having studied the colloidal reactions of the blood sera the author has no doubts that the collections of atoms in groups as colloidal particles has some definite effect in producing an easily controlled radio-activity, whereby the energy products are harnessed to the functions necessary to the living organisms. As new methods are devised, radio-active properties are being discovered in elements which have not hitherto been suspected of this qualities. J. J. Thomson has demonstrated the radio-active properties of potassium. Other quite ordinary elements can now be rendered radio-active under certain conditions, so that, really, the possibility suggested is not too fantastic in our changing world of to-day.

From a logical point of view it is not impossible to imagine the activity tending to flow in two directions as suggested. Returning to our formulæ we find that the resultant effect after combination has something to do with the power of activity of the atomic nucleus. For instance, in (1) the chlorine has the most powerful pull, and the effect is an acid or a desire to attract energy. In (2) and (3), the activities are balanced and the result is neutrality. In (4), the Na and the OH both tend to radiate activity, and the result is an alkali. Similarly (5), (6), and (7); although we have here three radicals in combination. Having these somewhat nebulous suggestions in mind we are in a better position to appreciate the effect of drugs and assess their value in an electronic capacity.

Dehydration, being the result of a radiation or disintegration of activity, needs drugs which will stop the process and repair the damage done by deficiency. It needs

alkalis, conductors of electrons, substances which are reduced by the blood constituents, i.e. oxidisers, drugs which lower surface tension, substances which diminish the calcium-potassium ratio, or agents which depress the thyro-adrenal group of glands — aspirin, trivalent arsenic compounds, insulin, vitamin D, etc.

Hydration, on the other hand, being an effect of “radiation” of activity inwards, or condensation, needs the opposite type of effect to break it up. It needs acids, reducers, or substances which can be oxidised by the blood particles, drugs which raise surface tension, increase the calcium-potassium ratio — glucose, oxygen, calcium salts, iodine, thyroxin, vitamin C, etc. These lists are not in any way intended to be comprehensive, but are only intended to serve as examples of the requirements.

Slight Dehydration requires the minimum amount of conduction of activity, which can be given by the administration of bicarbonate of soda either alone or in combination with potassium bicarbonate, nutritive salts or any of the many mixed alkaline salts on the market; aspirin or trivalent arsenicals are useful in the deeper grades. This slight dehydration is often met with in early cases of dental caries and gingivitis.

The more advanced type of dehydration is met with in staphylococcal infections, the lysis of which is best converted into dispersion in acute cases with manganese butyrate. If the infection is present for more than five days S.U.P.-36 should be used.

In streptococcal infections use S.U.P.-468.

In gonococcal infections use S.U.M.-36.

In some infections such as syphilis, complex arsenical preparations may be necessary, but these are not likely to need treatment in dental surgery and need only be mentioned for comparative purposes.

Gelation is best corrected with S.U.P.-36 or insulin. S.U.P.-36 acts as a conductor of electrons and restores the negative

charge and Brownian movement. Insulin is the body's own hydrator. Synthalin-B has been found useful in certain cases.

In gelato-hydration a decision has to be made as to which force is more active. If dehydration is to the fore this must be compensated first. If hydration prevails, glucose can be given intramuscularly and then S.U.P.-36 or S.U.P.-468.

The enumeration of the general principles above is not really very helpful except as a basis upon which to build. The obvious way in which to instruct the reader would be to describe the routine examination of patients, which is accordingly done in the follow chapter.

Before leaving the subject of the influence of drugs, mention should be made of some suggestions made by Randall (1937) on the effect of impurities in substances upon their fluorescing properties, which may throw some light upon the small quantities of certain elements which are at times found in physiological analysis. He suggests that certain compounds will only luminesce if small minute traces of certain impurities are present. His explanation is that the addition of small quantities alter the levels of energy and assist the moving electron to jump into an orbit more removed from the nucleus under the influence of certain rays. If this new energy level is not added, the pure substance has forbidden bands through -which the electron finds it too difficult to jump under the impressed energy of light rays. May it not be that herein we find an explanation of a catalytic action by small quantities of the heavier elements which are present in the body. The bridging-over of the zone forbidden to the electron would result in a more easy transfer of energy in the atoms and colloidal particles which is so necessary to life. The speculation is an interesting one and is well worth bearing in mind, as, it may help to explain the easy transfer of energy which is carried on in the blood-stream.

CHAPTER XIV

TREATMENT OF DENTAL DISEASE

The treatment of the various manifestations of dental disease along the lines suggested below does not necessarily belittle the usefulness of dental surgery. On the contrary, the recommendations enumerated are intended to assist treatment in a complementary way. When disease is so firmly established as to necessitate surgical procedure, it is better that orthodox treatment be administered to correct the damage already done to the tissues. As previously explained, the surgical procedure is for the most part merely palliative, and does not always get at the cause of the primary condition. Many cases will be known to the reader where complete clearances have eradicated general toxic symptoms; but, on the other hand, he will doubtless also be familiar with cases in which surgical means alone have failed lamentably to effect the desired result. The treatment by electrionic methods is calculated to bridge that gap for the common good. It may be used to explain failures, and by so doing turn them into successes. The beginner will need to tread cautiously for a time and experiment on the simpler cases first. As his clinical perception increases so will his courage and knowledge grow. Each failure should be used as a stepping-stone to further conquests. In order to assist the reader in the classification of types of treatment some of the commoner manifestations of dental interest are enumerated in this chapter. For convenience of reference they are arranged in alphabetical order. Whereas this list is not meant to be in any way comprehensive, it should nevertheless form a sturdy foundation on which the earnest research worker can build. The conditions enumerated clearly point out the method of diagnosis and

indicate the particular treatment that may be applied with good effect. Details may vary in certain cases, but all these must be examined and assessed in the light of the full information available about the individual case. Each patient must be treated on his or her own merits.

Acute Abscess is probably one of the commonest types of dental sepsis requiring immediate treatment. The condition varies from a small localised inflammation to an extreme case with its concomitant general toxic effect. The abscess is, no doubt caused locally by the bacteria, infecting the tooth, becoming more active owing to lowered resistance. The dentist who is called upon to treat these cases will, of course, operate in the milder cases immediately, and the swelling and pain will disappear. In the worse cases he may postpone treatment for a few days till the swelling subsides. As a rule this sequence is followed, but there are certain cases which progress adversely and may result in a cellulitis or other condition of similar nature often endangering the patient's life.

There is little doubt that the reason for this flare-up of an infected area, which may have been present for many years without apparent discomfort, is a sudden dehydration resulting in lowered resistance to the infective process and so allowing this to become active. When the balance between the electronic capacity of the colloidal particle and that of the bacteria is disturbed, with resultant lowered potential on the part of the blood, the bacteria is able to rob further electrical and other constituents from the, plasma. This produces an agglutination of particles, and probably some gelato-hydration locally, which obstruct the blood-vessels and cause oedema. The blood will in these cases always show some evidence of the condition. There will be myriads of tiny particles in the early cases, with feeble Brownian movement and a tendency to precipitate on the glass. Gelation and/or hydration may be in

evidence. In the cases which are more severe there will be a reduced number of particles, owing to the number which have been sent into true solution. The saliva will often test acid, although some cases may not give a true reaction owing to the presence of colloidal matter.

General treatment naturally consists of an attempt to correct the blood picture, with, of course, such surgical procedure as may be required. Alkalis will probably not act with sufficient rapidity. If the case is all early one, manganese butyrate should be injected; if the condition has been active for longer than five days, S.U.P.-36 or a trivalent arsenic would be more useful. Alkalis will, however, assist a quick return to normal, and often will enable a blood which has been robbed of electrons to build up its normal reaction quicker than by the administration alone of parenteral injections of the type mentioned.

Anæsthetics and their exact action on the human physiology, have not as yet been thoroughly explained. An examination of the serum just before and during the anæsthesia brings to light very interesting facts. The essential quality of a drug, which is required to produce narcosis is that it first brings about a sudden dehydration of the protein particles, and this effect is almost immediately followed by gelato-hydration or hydration. The resultant precipitation of particles causes a blocking of the blood supply to the brain cells and brings about the onset of unconsciousness. The various degrees and types of anæsthesia depend primarily upon the depths of dehydration and hydration respectively produced, together with the state of the particles before the administration.

Difficulties in the anæsthetic effects upon certain patients can easily be explained by the electronic change in the colloidal particle. In a very dehydrated case the induction will cause excitement, as, owing to the number of particles already sent into true solution, the further dehydration is of little avail, and the consequent small amount of hydration produced causes only

a light precipitation in the brain cells, resulting in an irritative process rather than a sleep-producing one, and the result is therefore a fractious patient.

Pre-medication to be effective must have the effect of returning the upset colloidal system to more normal conditions. Morphia and atropin are both hydrators, and consequently tend to increase the precipitant action and make induction easier to accomplish.

According to the previous history and blood picture, a hydrated patient should be medicated with arsenic (trivalent) compounds, S.U.P.-36, or other medicaments to ensure that a large number of more or less normal particles are ready in the plasma to bring about the effect desired by the administration.

From a practical dental point of the most troublesome post-anæsthetic worry is vomiting, especially after a large quantity of blood is swallowed. Therefore, as soon as consciousness returns, the patient should be given a tumblerful of water in which is dissolved a heaped teaspoonful of bicarbonate of soda. This acts as an anti-shock measure, and also by breaking up the coagulating blood, will settle the patient's stomach almost at once. Frequently it will enable most of the debris to be vomited up without effort, and another small dose of the salt will effectually reduce discomfort and the patient can rest comfortably.

Ether has probably a very pronounced dehydrating effect, which explains the number of cavities that tend to appear in patients' teeth a short time after an operation has been performed under its influence. Chloroform probably acts as a more powerful hydrator, and this suggests why its dangers are so marked in certain cases. The hydration occasioned is much more difficult to correct than dehydration. and consequently if chloroform is administered to a patient already heavily hydrated death may result. The modern basal anæsthetics such as evipan sodium also show a hydrating effect which is

particularly pronounced. In some cases observed, with quite the usual number of particles moving, the hydration was so severe that in the field of view of the ultra-microscope, practically all the particles were precipitated with one or two in slow movement.

Further work along these lines would probably reduce the difficulties in anæsthesia to a minimum. Space does not permit further comments on the subject at this stage, but the reader is referred to the case notes in which he will find more evidence bearing on the relationship of colloidal chemistry to anæsthetics.

Caries in teeth is a disease so common that it is scarcely regarded as serious, yet it is one of the symptoms of an electrionic deficiency in the body, which is the price the human being has to pay for civilisation. Soddy (1932) aptly says that “after having struggled so long to exist, humanity now exists to struggle.” McDonagh in all his books stresses the lack of co-operation and blames our present lack of essential knowledge largely to specialisation. The dentist will never find the clue caries in his own speciality while he regards a tooth as a tooth and not as a part of the body subject to all the upsets that modify life and health. Broderick (1936) attributes caries to an effect of dehydration — which, as the reader will now be able to see, is in expansion of his original theory of acidosis.

We can briefly review the matter and take the story of caries back to the electron in its relationship to the enamel structure. It has been shown in the first section of this book how a solution may be “acid” owing to a deficiency of electrionic potential, or to an excited state of the atoms in solution. The teeth are bathed in saliva which should be almost neutral (pH 6.8). They are supplied by a tiny stream of blood (pH 7.4) through the apical foramen. The small quantity of blood supply and the more or less copious supply of saliva probably have some effect in compensating for the apparent potential difference. From the electro-motive series we see that calcium is high on the list, and

will, for that reason, give electrons to any ionised hydrogen that may come into the sphere of influence. In a normal healthy person the tooth substance remains in status quo, but if there is a slight increase in hydrogen ions in the blood-stream an electrolytic action takes place and the calcium salts become robbed of their electrons and can no longer retain their original position in the crystalline structure of the tooth. The main result is a thinning of the enamel and a weakening thereof. Pits and fissures holding fermenting foods would naturally tend to produce a greater excess of H-ions at that point; bacteria would add to this effect. Approximal cavities can also be explained to some extent by a difference in potential between two adjacent teeth. A small pit then appears in one or both, this holds debris, and the subsequent result is decay in both teeth.

Treatment consists of correcting the upsets of the colloidal system. Broderick (1936) has had spectacular success with the administration of insulin to young patients with rapid caries. He has produced adventitious dentine in an amazingly- short space of time. Nevertheless equally good results can be obtained with alkalis, but the time required is longer. When treatment is commenced a regular dose of sodium bicarbonate, with or without the corresponding potassium salts, first thing in the morning for two or three weeks will often correct the acidotic consequences of dehydration. A course of nutritive salts to follow, lasting from a few months to a year or two according to the type of case and the results obtained. In the course of treatment, soft tender cervical cavities will often become brown, hard, and completely insensitive, and so long as the blood balance is maintained will not require cutting out unless exceptionally deep.

The Common Cold, although not actually a dental disease, is sufficiently popular to justify consideration. Here again we have a colloidal upset which doctors usually regard as a more or less natural event. The so-called 'cures' are numerous but

usually ineffectual. McDonagh (1936) traces the cause to an intestinal toxæmia. Be that as it may, the symptoms are nearly always the result of a sudden dehydration, which if allowed to progress by neglect or faulty medication may easily result in really serious complications. The cold may rightly be regarded as an infection, but nevertheless correcting the resulting dehydration in the early stages will usually render the cold abortive. Influenza has a similar effect, but deeper in degree. The treatment of either is generally effective if taken at the onset of symptoms. If not taken immediately the treatment necessary is more severe and not so certain of success. In the early stages a drachm or so of bicarbonate of soda will remove all traces of the symptoms in the short space of an hour or two. Sometimes it may be necessary to take three or four doses at intervals throughout the day to eradicate a bad attack. These draughts should not be taken too near meal-times. If the symptoms have been allowed to develop, a single injection of S.U.P.-3 will in the majority of cases suffice. The after-'flu and after-cold feeling of being run-down can often be eliminated in day or two by the administration of alkalis. This statement is not purely theory, as many personal friends and acquaintances of the author can vouch.

Denture Soreness has a nasty habit of appearing in some cases where dentures have been worn for some time. Providing the plates are a reasonable fit there should be no difficulty in wearing them. Should the colloidal balance become upset in an acid direction inflammation has a great tendency to appear, and a denture is a good excuse. Easing in these cases is sometimes of little use. Sometimes the actual soreness is under the gums and lies in the bone. These cases are more likely to be due to hydration and its concomitant softening of the alveolus. Treatment is obviously a correction of the existing upset. This does not exclude the possibility of surgical procedure being necessary, which should, of course, be carried out where

indicated.

Gingivitis must be differentiated from true pyorrhœa. It is usually portrayed by a pale or bright red gum according to the severity of the case. The saliva is usually thick and ropy. The mucous film on the teeth can easily be seen with a disclosing solution, sometimes it is obvious to the naked eye. Soft yellow tartar is usually present on surfaces of the teeth which are adjacent to salivary glands. The pH may be low, at times even below 6. The blood picture shows evidence of varying degrees of dehydration. Caries is usually present and is of the soft variety. Vincent's organisms are often found in abundant flora on the gum margins. There seems to be no clear line of demarcation between gingivitis and Vincent's angina, the condition being entirely one of degree. General treatment will usually clear up the milder cases in a week or two without any local medication whatsoever. Naturally the local treatment should not be ignored, as many patients whose gums are tender and inclined to bleed fall into lazy habits through ignorance of proper methods of hygiene. A number of cases of interest along these lines are included in the case notes recorded in a later chapter, and reference thereto should be made for further information.

Halitosis of a persistent nature is nearly always occasioned by some process of dehydration. Having excepted the usual local reasons of bacterial origin, bad smells in the mouth are occasioned by nose, tonsils, or stomach. Dehydration, owing to the resultant breaking-up of the colloidal complex, naturally sends certain odoriferous organic compounds into solution, and for this reason a dehydrated person will naturally tend to be more 'smelly' than a hydrated one. In these cases halitosis is usually accompanied by a certain amount of body odour even in some people who are of cleanly habits. Sweat of an obnoxious character is always indicative of dehydration and almost invariably can be eliminated by appropriate internal

treatment. Excess acid in the stomach or wrong food may often lead to halitosis. Occasionally bacillus coli with its typical smell may inhabit the upper region of the intestinal tract. Attendance to the necessary methods of hygiene in these cases will often eliminate most of the halitosis. If persistent, it may be cleared up by the methods advocated previously for correcting the plasma upset.

Hypersensitivity of the enamel and dentine is a dental phenomenon that has not been rationally explained. Following on from the electrionic conception of disease it is easy to see the cause and effect. The nerves are composed of chemical constituents which have a large store of electrionic power. Ionise the blood which bathes the nerves and some of the electrons tend to be withdrawn from the nerves, leaving them in a less stable state and more easily irritated. The effect of acid ions on the nerves can easily be demonstrated with lemon juice (citric acid) or a little dilute hydrochloric acid held in the mouth for a short time. The effect of hypersensitivity can easily be produced by these means. Long-standing dehydration causing ionisation of the tissues over a long period will naturally have a deeper and more prolonged effect, which cannot be obliterated quickly with an alkaline mouth-wash. The most effective way to treat these hypersensitive patients is to give them alkalis for a week or more before undertaking any extensive conservative work; the badly decayed tooth, necessitating a temporary filling, naturally being excepted. It is really astonishing to find how favourably most patients will react. Some patients who have always had a dread of dental work for reasons of painful manipulation will, after they have been assured by the first moments, sit quietly and allow extensive work to be performed without flickering an eyelid. It eliminates the necessity for local anæsthesia and applied medicaments for conservative operations. Occasionally a sensitive tooth may be found in a hydrated case, but this will usually be found on investigation to be due to some more local

cause and naturally will require local treatment.

Oral Sepsis is evident in a large number of mouths. So far dental science has not been able to give a satisfactory explanation of why one case, presenting mild evidence of oral sepsis, should give signs of general toxæmia, and another person, with a gross amount of sepsis, in evidence, should be apparently in perfect health and unaware of the lesion present. Electronic medicine offers an obvious answer. When resistance becomes lowered sufficiently for an effect to be apparent on the colloidal system the general symptoms of toxæmia show themselves. Proper attention to routine hygiene will obviate most of the outward signs of oral sepsis but, in stubborn cases treatment will have to be rendered to suit the condition of the blood picture found on examination of the case. In the majority of cases of advanced oral sepsis there will probably be a mixture of hydration and dehydration present, consequently care will have to be taken in arriving at the diagnosis of the type of upset prevailing. Cases of oral sepsis of an advanced nature need the usual routine local procedure, and these should be accompanied by the indicated general treatment as well.

Peptic Ulcers are almost invariably due to an excess acidity possibly reflected in some way from the stomach. Potassium chlorate is practically a specific and can be given in fairly large doses (5 grains t.i.d. or oftener) either in powder or tablet form. Painting with liquid carbolic acid (1 in 4 aqueous solution) is to be preferred to silver nitrate applications. Sometimes these irritating ulcers have an annoying habit of recurring, and this tendency may be eliminated by administration of alkalis over a short period.

Pregnancy is probably responsible for more cases of gingivitis than is realised. Fortunately most of these conditions correct themselves after parturition. Caries is also rampant about this time, as the old adage says "for every child a tooth." The effect of conception is similar to that of any other invader

which tends to dehydrate. Towards the end of the forty-week cycle the dehydration is replaced by hydration, which brings about the induction of labour. If dehydration was the tendency before the foetus commences to develop, naturally there will be an increase in this factor. If hydration was the preliminary condition, the health of the mother may actually be improved by a swing in the opposite direction, tending to bring the colloidal system to a more normal state. In practically every case of the pregnancy the condition can be benefited by a course of nutritive salts. McDonagh (1931) recommends S.U.P.-36 for routine use.

Dehydration being predominant at the moment of conception, the sex of the child will probably be a girl. If hydrated, the offspring will probably be a boy. McDonagh (1934) does not agree with this, as he emphasises the opposite view. Raymond (1934), however, in a summary of research work done on the Continent, arrives at a conclusion which upholds the statement made above. Whereas the factors predetermining sex are probably too complicated to give an accurate forecast in every case, there be no doubt that observation of dental patients at this time will bear out the truth of the observations made. The woman who has soft teeth usually has more females and the pyorrhetic gives birth to boys. Conception following quickly on a previous confinement may just catch the colloidal system before it reverts to its previous state, and this explains why sex is frequently alternated in some families. The study of if the gingivæ during pregnancy is a most interesting subject, as the whole gamut of various types of inflammation can be seen ringing the changes in the space of of a few months.

Vomiting and morning sickness usually happen in cases of severe dehydration, and can frequently be checked by administration of alkalis. Owing to the needs of the growing foetus most of the upsets of pregnancy are better corrected with mixed salts than by the injection of powerful drugs. These latter are useful to correct severe upsets, but cannot be expected to

supply the many alkali reserve salts which are so necessary for the growing foetus.

Pyorrhœa is often confused with gingivitis, and this is probably the basis of the advertising slogan which says "four out of five have it." In adolescents it is comparatively rare and is associated more with middle age and later life. Usually it is *pari passu* with at least one chronic disease condition. The pockets are true and run below the gum margins, and have therefore to be differentiated from the pseudo-pockets of gingivitis and Vincent's angina, which are relative in as much as they are caused by hypertrophy of the gums. The true pyorrhœa is typified by a peculiar bluish appearance of the interdental triangles with, in more advanced cases, a rolling of the gum margins and a continuation of the deep coloration all along the edges. In the buccal folds the little veins are more pronounced than the arteries. Cases of more or less pure hydration will usually clear in one or two months' treatment. Deep pockets cannot be removed by general treatment alone, and as a rule need cauterisation or gingivectomy according to the merits of the individual case. Mixed cases can be very troublesome, and require patience and prolonged treatment in order to produce anything like the desired effect.

Medication in the early cases can be given orally. Ammonium chloride in 15 to 30 grain doses can be taken in large amounts of water three times a day with meals. Given without meals or with insufficient water it may cause a burning sensation in the stomach. Mixed halogen salts are useful. Vitamin C is slow in action but can be helpful. Calcium injections can be given subcutaneously, a course of five, one each day; after a few days' rest they can be repeated, if desired. Constipation must be combated at all costs, as a sluggish bowel is one of the most potent causes of hydration. In bad cases a course of high colonic lavage may be necessary. This should not be done while any general condition is active, as it is liable

to cause a flare-up when first performed.

Syncope is a common cause of worry and trouble when it happens in the surgery. The patient is usually pale, sallow-complexioned person, suffering pain for some time previous to the visit. The excitement, followed by the injection of an anæsthetic containing adrenalin, is too much for the already dehydrated particles and they agglutinate in the abdominal viscera and the patient becomes unconscious for a time. The onset of syncope can usually be recognised before it actually occurs. The administration of a teaspoonful of bicarbonate of soda is an immediate specific for this type of syncope. After most stimulants the patient is only just fit to be helped out of the surgery, and this often necessitates postponing the operation. The sodium salt, followed by a few minutes' rest, will freshen the patient in an amazing manner and the operation can be commenced. Occasionally it may bring about a vomiting attack, but usually sufficient of the salt is retained to have the desired effect. If the syncope occurs before the operator notices its onset, the usual methods of procedure in such cases have to be adopted.

Tartar is of two types, the soft and the hard. The former is the result of dehydration and the latter of hydration. Lime is deposited out of the saliva by either of the two processes. The soft tartar is usually of a yellowish colour, and is liable to form on the surface of the teeth particularly near the orifices of the various salivary ducts. It is comparatively easy to remove, and can be prevented from being deposited by the appropriate treatment, for the degree of dehydration shown. The hard tartar is usually darker and finer in consistency, and is deposited just under the gum edge. It can be exceedingly difficult to remove. Being the result of hydration, prevention can often be undertaken successfully. It is important to remove all this subgingival calculus before attempting a treatment of any case of pyorrhœa, or a recurrence is certain at an early date.

Ulcerative Stomatitis and **Vincent's Angina** present many

features in common, and can therefore be considered together. The former has a slower onset and is a less severe condition than the latter. A mild gingivitis with lowered general resistance can easily lead to either of the conditions mentioned. The exciting cause in Vincent's angina is probably a superadded infection of an active organism from some external source. This is not, however, necessary, as the causative organisms are present in the majority of mouths in considerable numbers. The usual sequence of events can be seen in the blood picture in the same order as any other dehydration. The treatment consists of the usual arsenical lotions, with or without hydrogen peroxide washes as required. Generally the injection of a trivalent arsenical in doses, of .3 gram at three to four days' interval will bring the condition back to normal after a few weeks. As the conditions are infective, special precautions should be taken and the patient warned about the care of his toothbrush and utensils.

From the foregoing descriptions of the more common dental conditions the two factors causing disease should be apparent. Dehydration seems to be by far the most prevalent condition, although in some practices and certain localities the reverse might be found. The point to be stressed is that all disease results from a deficiency or a condensation of electrical energy. To treat the condition, one has to decide first the predominating element and its degree of intensity and arrange the treatment accordingly.

The thinking dentist can use dental medicine in a great number of his cases to great effect. The possibilities are enormous, and as yet, the fringe of the subject has only just been touched. When the details become familiar to the operator in practice he will be assured that herein lies the secret of health, the beginning and the ending of disease.

CHAPTER XV

DRUGS AS ENERGY CONVEYORS

To describe in detail the numerous drugs which are available for therapeutic use would merely constitute a cumbersome reference-book; and as the object of this work is to lay down certain fundamental principles this is obviously out of the question. It is, however, intended to describe briefly the form and function of a number of useful medicaments. It is hoped that the details recorded about the various reagents will enable the reader to realise that for the most part drugs merely act as energy conveyors. The cure effected is the direct result of a return of the colloidal system to a more normal state.

The selective action of a drug can be explained by the depth of variation of electrical charge undergone by the colloidal system, whether generally or locally, as a direct result of administration. For example, the electromotive series shows the relative capacity of various elements for robbing or donating electrons with relationship to hydrogen. In the case of colloidal particles the charge is not one of just an electron or two. These minute aggregations of perhaps several thousand or more atoms will have a charge capacity greater than a few electrons. Obviously this charge can vary within quite wide limits. As the particles are somewhat similar in action to travelling storage batteries carrying potential from the intestines to the tissue cells, it is apparent that a lowered or increased potential will effect the comfortable balance between the various parts. Consider the effect of overwork on a muscle, the after effects locally and generally point to a difference of energy-level by production of acids. Electrionic potential has been changed. It should be easy to follow the manner in which an upset colloidal

system, with a definite potential difference from normal, has a selective action in producing, abnormal effects on some part of the body. Obviously the potential of each type of cell is different in capacity owing to its type of function and chemical structure. This, therefore, will produce an upset in the normal interchange of energy and may starve the tissues of a certain part or organ. With an increased positive charge there is a tendency for the particles to repel one another less, thus a definite attraction between the organs and the particles may be set up. This would tend to block the arterioles supplying those organs. Something of this nature probably occurs in conditions such as anæsthesia, pneumonia, œdema, and many others.

In treating a dental condition, therefore, in which there is an advanced disease present, it is probable that treatment with a drug known to be suitable for that type of electronic disturbance will be most useful. Here we see that dental medicine is not at all at variance with orthodox practise, but provides a sure foundation on which to test our diagnosis, and helps in the choice of suitable curatives for administration. For the same reason it should be obvious that a long

standing condition will have produced such a stable type of upset, and one of such a deep root, that a cure cannot be expected quickly; although in many cases the speedy reaction may surprise even the most optimistic. As most of the conditions met with in dental practice are not of a very difficult nature, the dental physician should have no hesitation in taking complete control over treatment. Those cases of long-standing chronic disease associated with pyorrhea are probably best undertaken in collaboration with the patient's medical adviser. If the latter be approached, he is often quite helpful and sometimes even pleased to try any line of treatment which he had not considered. Dentistry to-day lacks faith and pride in itself. If it had a little more courage to consult with the medical adviser in difficult cases, with a view to co-operating in

treatment, it would soon become appreciated more fully as a speciality of the healing art instead of being regarded as a legally and ethically separate profession.

After this preamble it should now be possible to follow the line of thought indicated in the description of the following medicaments, which should form a useful selection upon which the practitioner can build. For the sake of convenience they are arranged in alphabetical order.

Acetylcholin is the acetyl derivative of hydroxy-ethyl-trimethyl-ammonium hydroxide, a base that in combination with glyceryl-phosphoric acid and fatty acids exist in many living tissues such as brain, nerves, and cell membranes. It stimulates the parasympathetic and consequently has an action equivalent to that of hydration. Amongst its clinical applications are the conditions of post-operative paralytic ileus, as a vasodilator in peripheral vascular disturbances, Raynaud's disease, angina pectoris, endarteritis obliterans, migraine, arthritis, and epilepsy; Broderick (1936) indicates its use in caries. It is best administered intramuscularly or subcutaneously, as some authorities affirm that oral use is of little avail. It may be given in quantities ranging from 0.01 to 0.6 grammes. The small quantities may be given up to twice a day and the larger quantities at longer intervals.

Ammonium Chloride is useful in some of the milder cases of pyorrhoea. The ammonia group is easily eliminated by the kidneys, and the chlorine ion is therefore free to neutralise the alkalinity prevailing. The dose is about 10-20 grains three times a day, and can be taken at mealtimes. If taken on an empty stomach or with too little water there may be a burning sensation. It is a simple compound, and unless given over long periods is unlikely to cause any distress. The single salt is not, however, so effective as a mixture in the majority of cases.

Arsenic is a heavy element of group V; with the atomic number 33 and atomic weight 74.9 it has a probable electron

arrangement from within out of 2, 8, 18, 5. With three electrons missing to complete its outer octet it can have a valency of five to three according to whether it tends to donate or lose electrons. In the former case it acts like a metal and in the latter as a non-metal. Thus can be explained the fundamental differences between a pentavalent or a trivalent compound. From these observations it can be seen why the two types have different physiological reactions. The trivalent compounds are more useful as tonics in early disease to restore charges in the colloidal system, and the pentavalent in chronic cases to break up hydration of a deep nature. The former is used in early cases of syphilis and the latter in advanced cases. Arsenic has many uses, but first will be described two typical applications which have been found very useful in practice.

An effective prescription for gingivitis which needs a local tonic application is:

R₇ Liq. arsenicalis.
 Vin. ipecacuanhæ a.a. $\overline{3}$ ff
 m. ft. lotio.

Sig.—A few drops on the dry toothbrush, to be well massaged into gums after thorough cleansing

This preparation has a very stimulating effect on sluggish gums to assist general treatment in most cases of gingivitis, especially if spirochætes are present.

For many years the author has used and recommended a tooth-paste containing arsenobenzol in suitable cases. It is a most useful adjunct in practically all cases of gingivitis and pyorrhœa in which spirochætes and fusiform bacilli have been found or suspected. The preparation is marketed under the trade name Sanogyl by the Sealand Trading Co. London, W.C.2. The formula of this paste is appended:

R7 Calcium fluoridium	12
Calcium carbonicum	18

Glucerinium	60.5
Acid acetyl-amino-hydroxy-phenyl-arsonicom	0.4
Sapo med.	8
Olea ætherea	1
Carmium	0.1

The figures are percentages.

Colloidal arsenic (Crookes) is a mild way of administering this element where intolerance may have been shown by other compounds. This brand contains colloidal arsenious sulphide (As_2S_3) in the proportions of one part per thousand. 1 c.c. therefore contains approximately .0013 gramme arsenious acid. It can be injected in 1 c.c. doses twice weekly or given orally about a teaspoonful ex aquam p.c. t.i.d. It is recommended for use in trypanosomiasis, blackwater fever, anæmias, as well as subacute and chronic skin diseases. These latter being obvious manifestations of a dehydration, the use of a negatively charged compound is indicated.

Sulpharsphenamine is a very useful trivalent compound of arsenic, and can be administered either by the deep subcutaneous or the intramuscular route. It is an orange-yellow powder and contains approximately 20 per cent. of arsenic. Chemically it is disodium-3-diamino-4-dihydroxy-arsenobenzene-dimethyl-bisulphite. It is readily soluble in water and gives a faintly acid solution. It is marketed under the trade names Sulphostab (Boots) and Metarsenobillon or M.A.B. (May & Baker). Its dosage varies from 0.01 to 0.60 gramme given usually at intervals. For treatment of dehydration of the degree met with in Vincent's angina, and the like, the dose is better increased to about 0.3 gramme and given every three or four days according to the resulting reaction. Further details can be studied in the case notes.

Neoarsphenamine is another useful preparation, which is probably slightly more powerful than the previous one. It is

more suitable for intravenous injection. Chemically it is sodium - 3 - diamino - 4 - dihydroxy - arsenobenzene - N - methylene - sulphoxylate. It is a yellow powder containing about 20 per cent. arsenic, soluble in water, but yields a neutral or faintly alkaline solution. The dosage is similar to the previous preparation.

It is usually recommended when administering arsenicals to alternate with the administration of other substances to neutralise the effect of arsenical poisoning. Trivalent arsenicals are not likely to produce any symptoms of toxæmia when used to relieve dehydrations. But, if a fair amount of deep hydration be present, it may be necessary to supplement treatment with a drug such as sodium thiosulphate or calcium thiosulphate, which would tend to neutralise the excessive hydration.

The pentavalent compounds are mainly used for breaking up the severe degree of hydration occasioned by longstanding venereal disease, and as such are not likely to be of much use in dental practice. One compound which can be taken by mouth, however, is 3 - acetylamino - 4 - hydroxy - phenyl - arsonic acid, a white powder almost invisible in water and containing nearly 30 per cent of arsenic in organic combination. It is marketed under the name Stovarsol (May & Baker) and Orarsan (Boots). Each tablet contains 0.25 gramme, and may be given twice or three times a day for a week or two. It is advised in treatment of leucorrhœa, colitis of non-dysenteric origin, in addition to amœbic dysentery, yaws, and syphilis.

Aspirin, or more accurately acetyl - salicylic acid, is a very mild dehydrator. It acts probably by breaking-up the particles and so increasing their surface area. This explains why it may be of use in colds, but if the condition is advanced it is practically useless. By increasing the temperature it is possible that it may assist in combatting the bacteria causing the infection. In cases of relief of pain it probably acts by

correcting the local disturbance which is the cause of same.

Atropine is an alkaloid obtained from plants, sometimes given in the form of the sulphate $(C_{17}H_{23}NO_3)_2H_2SO_4$ as a subcutaneous injection with or without morphia before an anæsthetic. The dose is from 1/200th to 1/100th grain parenterally, or it can be given in 1/50th grain doses by the month, in which case the action is slightly slower though none the less effective. It is powerful hydrator, with a selective depressant action on the salivary glands.

Belladonna (Tincture of) contains 0.035 gramme per 100 millilitres of the alkaloids contained in the leaves. The dose is 5 to 15 minims. Broderick (1936) recommends its use in treatment of pyorrhœa as a depressant of the parasympathetic. Although this action seems to be at variance with the previous remarks, it may possibly have some selective action in that direction.

Calcium is a divalent element of atomic weight 40.07 and atomic number 20. Its probable electron arrangement is 2, 8, 8, 2. It is just before that element in the first long series where the inner M shell starts increasing from 9-18 (scandium - zinc) while the N or outer shell remains helium-like with two. It is fairly high on the electro-motive series. Broderick (1936) describes its antagonism for potassium, as probably due to its tendency to stimulate the sympathetic. Although this is admitted by many writers, the author is inclined to the view that calcium acts also in some manner as a flux or catalyst for liberation of energy in the plasma. The peculiar halation effect of calcium adsorbed to the micellæ has been described before, and this is almost a typical characteristic of a slightly dehydrated blood. A hydrated particle may be powerfully refractile, but it will not exhibit the same diffusion effect. Crystals, probably composed largely of calcium, can occasionally be seen in certain bloods where the forces of disintegration are powerfully at work. These show an intense

radiation of activity when first examined, which gradually disappears. This activity, as shown by definite radiation, is often more powerful than the similar phenomena observed in crystals that form in colloidal calcium slides.

The use of calcium to neutralise an acidity would seem therefore to be contra-indicated. Its chief benefit would be derived in cases of pyorrhœa or calcium starvation. There are many forms in which calcium can be used. Given orally is the simplest, but authorities are not unanimous in the results achieved. It must be given 10-20 grains before a meal or with a light acid, such as dilute hydrochloric acid, in water. This method of administration is not always reliable, and results may vary considerably. The most satisfactory method to adopt is to inject subcutaneously colloidal calcium and ostelin (Glaxo). Each dose of 1 c.c. contains 5000 international units of vitamin D and 0.5mg of colloidal calcium. A course of six daily injections may be repeated after a few days' rest if desired. It is recommended for catarrh of the mucous membrane, urticaria, asthma, migraine, and eczema and allergic reactions.

Glucose is classed as a dehydrator by McDonagh (1927), but as it is one of the important carbohydrates from which the body obtains its energy, it is likely that its function as a fuel is more important. Its use is chiefly indicated in those cases of dehydration where the supply of carbohydrates has been decreased. In short, its function as a dehydrator is relatively unimportant except perhaps in cases of insulin shock. It is recommended for use in all acute illnesses and fevers, pre- and post-anæsthetic medication, vomiting and debility, acidosis, pneumonia, influenza, and many other conditions of a similar type. It can be given orally or intravenously. The dose may vary from a few drachms to a pound or two per day.

Halogen Salts of Magnesium are very useful in cases where the hydration present is not too severe. They are

marketed under the name Halmogen (Tonicity Laboratories, Ltd.) and each 0.45 gramme tablet contains:

Magnesium chloride	0.359 gramme.
bromide	0.0133 „
iodide	0.000067 „
fluoride	0.0006 „

Excipient q.s.

m. ft. tab.

They are recommended by the makers for numerous conditions. In certain cases, no doubt, they may have some value as a tonic. The magnesium radicle is not a very powerful one from a basic point of view, whereas the halogens are strong from an acidic aspect. They will be found quite useful in cases of pyorrhœa, which are not too chronic. They may prove useful as an adjunct to treatment of dental cases associated with low blood pressure, neurosis, catarrh, allergic condition,, cramps, chilblains. They are also likely to be of assistance in those cases of female irregularities where periods are delayed and have a tendency to painful commencement due to excess clotting. In some cases of sore gums under dentures they are invaluable.

Hydrochloric acid (dilute) of the B.P. contains 10 per cent. by weight of the acid dissolved in water. It forms a useful drug for patients who will not tolerate certain other dehydrators,. Being a normal constituent of the gastric juices it can easily be taken in a little water at mealtimes. The dose is 10-20 minims and can be given three or four times a day as required. Care should be taken when using it in cases of hyperchlorhydria. It has been recommended by Green (1934), diluted to 1 in 1000 for intravenous injections as a stimulant to tissue activity. No doubt it would act in this manner, but the oral route is certainly safer. Generally its use is best restricted to cases of hydration. But in certain cases of calcium shortage due to a hypochlorhydria, Broderick (1936) suggests that it may be

necessary to administer the acid together with calcium as a preventive caries formation.

Insulin, according to McDonagh (1927), is the body's natural hydrator. When first discovered, it was used almost exclusively as a control of sugar metabolism in diabetes. Of recent years it is being used much more freely in other suitable conditions. Each clinical unit contains about 0.00005 gramme of solid insulin, usually as the hydrochloride. The dose according to condition and requirements may be anything from one or two units to as much as 200 in very severe cases. This may be administered hypodermically twice a day or less as indicated. It should prove useful in practically all cases showing signs of "acidosis." Levy (1926) has found it useful in the toxæmias of pregnancy. Fisher (1926) recommends it in surgical shock, post-operative vomiting, and allied conditions. Broderick (1936) has found it beneficial for treatment of caries. The best dosage in these types of cases seems to be from 5-10 units given daily for anything up to two or three weeks. Unfortunately the effect of insulin is not lasting, and the improvement may not be maintained in some cases unless suitable regulation of diet is advised. There are certain possible dangers associated with injection of insulin which have to be borne in mind. Sugar is probably best given by mouth a short time before, and, if necessary, can be injected as a solution of about 20 to 30 grammes of glucose in a 20 to 50 per cent. concentration. Alternatively 1 c.c. of a 1 in 1000 solution of adrenalin or 10 units of pituitary extract should have a similar effect. In a case of pure dehydration or acidosis there is little likelihood of unfavourable reaction. But should there be a fair degree of hydration already present the symptoms of insulin shock may supervene a short time after administration. If the blood picture is carefully examined previously there should, however be no real difficulty.

Iodine is the heaviest halogen, with a probable electron

arrangement of 2, 8, 18, 18, 7. Its atomic weight is 126.9 and atomic number is 53. Lacking one electron in its outer shell it has therefore a powerful desire to complete its outer octet. This will tend to rob electrons from substances with which it is brought into contact. It is usually used as the tincture *iodi. mitis*, which contains about 1/44th of a grain in each minim. The dose is 2 to 5 minims. This can be safely exceeded if given in large amounts of liquid (e.g. milk or soup, etc.) and taken three times a day. Years ago it was popular in the treatment of pyorrhœa, and there is no doubt of its efficiency in many cases of chronic sepsis. In addition to its action as a dehydrator it has also a useful action as a disinfectant of the alimentary canal. Its action as a stimulant of the thyroid gland is well known to need elaboration here. A mild way of using iodine is the colloid form (*Collosal*). Each drachm contains 1/6th of a grain of iodine and can be taken, if required, over long periods without distress. Salts of iodine have many uses, they have probably a similar effect in a milder degree stage.

Manganese Butyrate is a most useful asset in cases of acute sepsis. The mode of action is difficult to follow accurately, but it is probable that it acts as a hydrator by conveying electrons to the particles in early sepsis; if the condition has been present some time it may have the opposite effect and tend to aggravate the condition. In cases of acute sepsis that are not of longer than five days' duration it should be injected intramuscularly, 1.5 c.c. of a 1 per cent. solution. A second injection may be given about four days later if required. They should not be repeated until two months have elapsed. Its action is spectacular in suitable cases. Instances of its use are given in the next chapter.

Morphia, in common with the other alkaloids, has a powerful hydrator effect. It is to this that its sedative action is probably due. Except as a preliminary to anæsthesia and in cases of extreme pain it has very little place in dental medicine. Other preparations can be used with less danger and probably

equal effect. One point which has been noticed in the use of morphia is that it works far more effectively in dehydrated cases. Hydrated patients always seem worse generally after morphia, and healing is slower and soreness far more lingering.

Nutritive Salts are manufactured in 15-grain tablets by Parke, Davis & Co. Ltd (C.T.600). They contain salts of calcium, magnesium, sodium, potassium, manganese, iron, etc. in a physiological balance. They are of extreme value in supplementing a demineralised diet and combatting acidosis. In the typical cases of early acidosis the author usually uses mixed bicarbonate of soda and potassium for about a fortnight, and then continues treatment for about three to six months with nutritive salts. The dose is $\frac{1}{2}$ to 1 tablet per day for children and 2 for adults. They can be dissolved in soda water, or crushed and suspended in water, milk, or other liquid and flavoured to taste. Containing as they do a good mixed variety of the salts normally present in the plasma they are capable of restoring and maintaining the alkali reserve in a way which cannot be achieved by a single salt such as bicarbonate of soda.

Oxygen is capable of liberating energy from carbohydrates, as its action in the body shows. Its atomic number is 8 and atomic weight 16 with a probable electron arrangement of 2,6. It is, therefore, obviously a reducing agent, which seems at first to be a contradiction of the word "oxidation". Its main method of use in dental medicine is by injection of 500-1000 c.c. subcutaneously. Broderick (1936) describes his apparatus, and reference can be made to his book for details. He has found oxygen very useful in treatment of pyorrhœa and associated conditions. It is possible that a great deal more will be heard about this in the near future in connection with the treatment of other chronic conditions.

Potassium Bicarbonate is very similar in appearance and action to the sodium salt. In cases where the K-Ca ratio needs

increasing it is probably more useful. Having used this salt alone and in conjunction with its sodium counterpart it seems that the use of the two salts is possibly the more beneficial.

Potassium Chlorate is another useful salt, and is of great value in cases where the oxygenating properties are advantageous. Ulcerative conditions react more favourably to the chlorates. The dose is 5 to 15 grains, but this can be exceeded without detriment. In cases of local ulceration of the mouth the salt may be obtained in small tablets which can be sucked, and thus exert a prolonged contact with the area involved.

Potassium Citrate is somewhat similar in action and has a much more pleasant taste; the dose is 15 to 60 grains.

Sodium Bicarbonate is one of the most useful substances for quick neutralisation of a slight acidity or dehydration. It needs, however, to be taken in large doses of up to a heaped teaspoonful in a tumblerful of water some time away from a meal, preferably about an hour before breakfast. If taken near a meal time it meets the HCl in the stomach and passes down the alimentary canal as a neutral salt. Taken when the stomach is empty it is almost immediately released by the pyloric sphincter and absorbed into the system to act as an alkali. On meeting an acid such as HCl, salt (NaCl), water (H₂O) and carbon dioxide (CO₂) are formed. The two former are neutral and the CO₂ is quickly eliminated by the lungs. After a tiring day's work a dose of sodium bicarbonate will refresh the weary body in a matter of minutes. For assisting to throw off after 'flu feeling it is very useful. It is a specific against syncope brought about by nervous reactions. When the acidity is neutralised the alkali reserve can then be replenished by the administration of mixed salts as already described. Patients with hypersensitive teeth after a week or two on sodium bicarbonate can be treated for fillings without injections, as the teeth will have become almost insensitive.

Strychnine is a member of the alkaloid group. However, in minute doses, it acts as a useful tonic with which to complete a course of treatment for alkalinising. A useful prescription is as follows:

7	Tr. gent. co.	mXXX.
	Tr. nux. vom.	mXV
	Aqua. chlorof. ad.	℥ ff
	Mitte as required.	
	Sig.— ℥ ff. ex aqua. t.i.d. p.c.	

This forms a strong tonic which will round off a course of treatment very successfully. It is very stimulating, and therefore should not be taken late in the evening before retiring.

S.U.P.-36 is the sodium salt of the symmetrical urea p-benzoyl-p-amino-benzoyl-8-naphtol-3 : 6-disulphonic acid, a condensation product of the dye intermediate 'H-acid.' It has a somewhat different action to manganese butyrate, and therefore can be given in septic cases which have persisted for more than five days. Its action in suitable cases is dramatic. It is recommended for use in influenza, pneumonia, all infections of some days' duration, skin affections, and many others. It is given intramuscularly in doses of about 0.01 gramme per c.c. in isotonic solution. The injection may be repeated on the next day and again about three days later if required.

Vitamins are fashionable, and therefore merit brief inclusion in this chapter. Apparently these substances act more or less as catalysts or surface activators. They seem to effect oxidation and reduction in the body out of all proportion to the quantities in which they are present. A great deal of work yet remains to be done along these lines, but a brief description of some of these substances is given to assist the reader in his choice.

Vitamin A is a hydrator. A deficiency gives rise to pneumonia, gastro-duodenal ulcer, or urinary calculus, all of

which are symptoms of dehydration. In some measure, too, it assists growth and protects against infections.

Vitamin B is also probably a hydrator. Deficiency leads to certain anæmias, atrophy of the intestinal wall, and lymphoid tissue, together with loss of appetite and cessation of growth. Vitamin C, or alternatively ascorbic acid, is essentially a reducing agent. It is eliminated in the urine, and therefore needs constant replacing. It seems to be necessary to pregnancy and lactation. It also assists cell function in some way not quite understood. Scurvy is the chief symptom of a deficiency.

Vitamin D can be obtained by radiation of ergosterin with ultra-violet light. It is anti-rachitic and therefore a hydrator.

Vitamins are deemed by modern research workers to be necessary constituents of food, and many manufacturers have marketed various preparations containing these vitamins. Apart from the usual articles of food and patent preparations containing vitamins, a number of concentrated preparations are sold which can be very useful in cases where a vitamin shortage is suspected.

Multivite Pellets (British Drug Houses) contain vitamins A, B, C, and D in balanced proportions. The dose is 1 to 4 daily. They are chocolate-coated, and being quite pleasant to take can be crunched or swallowed whole as desired.

Ostelin (Glaxo) liquid is another useful way of administering vitamin D. The dose is 2½-5 minims t.i.d. It is obtained alone or in combination with colloidal calcium.

Redoxon (Roche) is synthetic vitamin C and can be obtained in tablets of 50 milligrammes, which are convenient to take. It appears to be useful in cases of early pyorrhœa, but as it has only recently been marketed in a pure form more definite statements cannot be made at this time.

Vigantol (Bayers) is concentrated vitamin D and should be given in doses of 2-10 milligrammes daily. It can be obtained as solution, ovoids, or pellets.

From what has been written about the foregoing medicaments it is hoped that the reader will have obtained some insight into the action of drugs as seen through the eyes of electrionic medicine. These few remarks and the routine deductions recorded should enable him to apply the same reasoning to other drugs in common use. Certain conditions are obviously caused by dehydration and others by hydration. After some experience of the relative importance of these details, he should be able to say confidently that if a drug alleviates a condition of dehydration it obviously must be a dehydrator. More accurately, if symptoms of lack of electrionic energy are to be removed, they should be removed by a drug which can supply electrionic energy of similar power.

On these fundamental principles, then, the science of electrionic medicine rests; and there is no doubt in the author's mind that the recognition of these principles would lead the way to a more definite and simple preventive and curative medicine and eventually lay the foundations for a new era in which health would be assessed at its true value.

CHAPTER XVI

CASE NOTES

The final phase in this study of electrionic medicine is now reached. Having considered the underlying theories it is next necessary to examine these in the unbiased light of practical experiments. To that end this chapter is devoted to the consideration of notes on selected cases. As the reader peruses these records it is sincerely hoped that he will see how this new type of treatment will expand his routine clinical ability. It should enable him to deal adequately with a type of case which previously might have puzzled him, or perhaps would have lingered on until Nature herself saw fit to bring about a return to more normal conditions or otherwise.

From the cases selected it should be comparatively easy to see how the electrionic idea is applied in practice to diagnosis and treatment. The cases have been deliberately chosen in order to give a representative picture of the more common conditions met in dental practice. From the illustrations the reader should be able to apply the same principle to almost any case he is likely to meet in his everyday routine.

Once more it must be repeated that the treatment suggested is not an alternative to orthodox procedure but rather is it complementary. The practitioner has here a method which will assist diagnosis and treatment, thus amplifying his skill and enabling him to bring certain cases to a more successful conclusion than could be done with his present methods.

The recorded cases are meant to form a basis upon which the reader can build further knowledge and experience. For ease of assimilation the cases are recorded in order of complexity-the simple cases first. To eliminate unnecessary repetition similar

types of cases have been illustrated by a single example.

Case No. 1

Light Gingivitis.

Sodium Salts.

Miss E.M., aged 34, presented on 10.9.36 for gum treatment. The gingivæ had a red inflamed border, and apart from a pale appearance generally seemed fairly normal. Her saliva pH was 6.7 rising to 6.9 on standing, denoting an apparent acidity due probably to dissolved carbon dioxide in solution.

The blood picture showed large numbers of particles which had a great tendency to precipitate on the slide and adhere to blood corpuscles, indicating a slight dehydration. Patient was put on a course of bicarbonate of soda, and when seen a fortnight later, her gums appeared to be quite normal, in spite of the fact that no local treatment was advised.

Case No. 2

Gingivitis.

Potassium and Sodium Salts.

Mrs K.L., aged 24, mother of two children, a boy and a girl, presented for gum treatment on 14.1.37. The gums were pale generally with a swollen red line at gingival border. She had a history of frequent scalings, as tartar formed very readily on the lower teeth. Her saliva pH was well below 6.

Her blood picture showed a fair number of particles moving, mostly small. A few refractile particles were precipitated. Occasional aggregations and a few pseudo-spirochætes could be seen. The blood corpuscles had particles adhering to envelopes.

Treatment.- Patient was instructed to use an arsenic preparation locally and to take potassium and sodium

bicarbonate (mixture of equal parts) in water before breakfast each morning.

A fortnight later the patient's condition was much improved

and the pH was now 6.6. A scaling was done, and when she returned for examination (11.2.37) three weeks after her first visit her gums appeared to be in perfect condition.

Case No. 3

Pre-natal Gingivitis.

Sodium Salts.

Mrs M.L., aged 39 was four months pregnant on 14.11.35. Presented for scaling and treatment of gingivitis. The gums were pale with swollen red margins. As the pH was 6.1 patient was advised to take a teaspoonful of bicarbonate of sodium a tumblerful of water each morning one hour before breakfast.

On 21.11.35 the gums showed considerable improvement. Several fillings were done on subsequent visits.

On 12.12.35 her gums were apparently in normal condition, but patient was advised to continue treatment as a prophylactic measure until confinement.

On 9.7.36, one month after her confinement, patient's mouth was in perfect condition except for two small cavities. She stated that her confinement was the easiest she had ever had, although the baby, a boy, was large.

Case No. 4

Surgical Premedication.

Sodium Salts.

Miss G.M., a shop assistant, aged 17, presented at hospital for severe neuralgia and pain from large ulcers over roots of $\overline{3|3}$. X-ray examination showed $\overline{8}$ to be impacted and septic. Her saliva pH was 6.2.

Blood picture showed a diminished number of particles moving, both small and medium. There were a large number of small precipitated particles. The blood corpuscles corpuscles were crenated and had small particles attached.

Treatment:- The ulcers were lightly painted with a strong aqueous solution of phenol, and patient was instructed to take

sodium bicarbonate in large doses daily. When seen one week later patient's condition was much improved. Pain had completely disappeared and ulcers were no longer present. 8 was surgically removed under nerve block. A week later, when the sutures were removed, patient reported that she had had no swelling and practically no pain from the operation.

Case No. 5

Pre-natal Gingivitis. Potassium and Sodium Salts.

Mrs C. S., aged 21, was referred to hospital for routine examination from the pre-natal clinic. When seen on 1.4.37 she was unaware of any discomfort except for a slight bleeding from the gums. Oral examination showed nearly all teeth to be present and sound. The gum margins were inflamed generally, particularly left side upper and lower, which were hypertrophied. The gingivæ about the teeth were red, and looked as if the surface layers of the mucous membrane had fallen off, showing the tiny capillaries lying almost on the surface. The patient was put on large doses of potassium and sodium bicarbonate. When seen again three weeks later the swollen gums were almost normal, and except for a slight marginal redness the mouth seemed health. Bleeding on brushing had ceased. No additional local treatment was advised or done, owing to the confinement being so near. The patient was instructed to continue taking the powder prescribed. At this late stage of gestation it is almost impossible to maintain an absolutely normal condition of the gums, but if the appearance is only slightly disturbed the treatment is probably best kept at a minimum until after parturition.

Case No. 6

Chronic Gingivitis.

Mixed Salts.

Recently the author met an ex-classmate at an Annual Dental Meeting of the B.M.A. This professional colleague was

distressed about the general condition of his gums and had contemplated having a clearance. After some conversation he became interested in the possibilities of electronic medicine, and, on the principle of “try anything once”, determined to see what could be done along the lines specified. Briefly his condition appeared to be one of chronic gingivitis, and, although tests were not available at that time, his macroscopical appearance and symptoms were such as to indicate an “acidosis”. Accordingly he was advised a course of nutritive salts. The progress and results are best given in his own words, taken from his letters some months later:

“With reference to the history of my oral condition I am afraid that in the early stages of the trouble I failed to take much notice of it, except the fact that the gums bled if interfered with in any way and, of course, there was little pain or tenderness of any sort, but an unpleasant odour was present. There was some gum recession, but not more than one usually associates with a person of my age. Your treatment as outlined certainly produced a healthier condition of the gums, the inflamed and darkish colour being replaced by the more natural pinkish hue, and the odour is less noticeable, and bleeding occurs less often. This is brief my- experience and I trust you will find it helpful in your work.”

Another letter adds:

“You will probably be surprised to hear from me, but I had promised, if you remember, to let you know how your course of treatment was progressing, and with the approach of Christmas, I thought it would be a suitable time to do so. I am happy to inform you that the condition of my gums is vastly improved, there is little discharge of pus, although definite pockets are established, and they have taken on a more normal colour; in fact a general all-round improvement, for which I thank you.”

*Case No. 7***Severe Mixed Gingivitis. Sodium, Potassium and Halogens.**

Mr B.H., a farmer, aged 27, was referred to hospital for gum treatment on 27.5.37. His history was that about five months previously he had had a bad attack of 'flu which left his heart weak. In spite of continuous treatment from his medical attendant he still had severe palpitations and "flutter" after exertion. His skin was damp, pale, and sallow; he looked septic. The gums were swollen and bluish in colour, very little tartar was present and small amount of caries. There was a soft sludge on teeth and gums. In fact he presented most of the symptoms of hydration and a few of dehydration. His pH was 7.1.

His blood picture was as follows. There were about the average number of particles moving. Some were very large and refractile, while some were very tiny. Numerous crystals were found; these looked very similar to those which form in serum that has recently been under the influence of deep X-ray therapy or radium treatment. The radiation from the crystals indicated an intense activity of some kind. A number of pseudo-spirochaetes were present. A large number of very tiny particles were precipitated on the slide. The serum was thin and watery when the coagulum formed. The surface tension lowered. Overnight a large amount of lysis was obvious by the dropping of corpuscle casts to the bottom of the tube.

He was treated with potassium and sodium bicarbonate for one week with marked improvement. His pH had then reached 7.6. His heart had stopped fluttering, although his gums were still congested. He was next given a course of mixed halogen salts for a fortnight, after which his gums became practically normal, and he felt quite fit again in himself. His skin was clear and pink.

His blood picture, however, was still one of marked

hydration, but there was little evidence of disintegration. There were a fair number of particles moving, many of which were large and refractile, and occasionally showing evidence of capsule formation. He was instructed to continue with halogens for a few weeks as a precautionary measure.

This case' is one of interest as showing how the dehydration resulting from an attack of 'flu upsets the more or less normal (to that patient) slight hydration.

Case No. 8

Acute Post-Operative Sepsis. Manganese Butyrate.

The patient, Miss D. A. P., aged 24, had a history of frequent illnesses since she was 17. At this age the, trouble began with a badly swollen gland on the right side of the neck, followed by severe tonsillitis; there was a subsequent record of bronchitis and frequent colds with recurring attacks of intestinal and nasal catarrhal infections; in fact, T.B. was suspected by two medical men, although the sputum test proved negative each time. On no occasion was there any suggestion of pain or discomfort locally from two lower impactions, although the patient had complained of recurring pains in the back of the head and in the malar region. The other teeth although heavily filled were in good condition, but there was a slight inflammation of the gingivæ, with a rolled appearance which was slightly bluish. The right impaction, which was deep, was removed surgically under block anæsthesia. After-treatment of the case consisted of hot antiphlogistine applications and allonal tablets. Four days later there developed a severe general toxæmia, accompanied by a flare-up on the other side of the jaw, with pain and swelling. The toxic symptoms were so severe that a subcutaneous injection of manganese butyrate 1.5 c.c. was given. The temperature was lowered in a few hours, and this was followed by uneventful healing. The surgical

details of this case have been previously described elsewhere [Torrens (1936)].

Case No. 9.

Dental Sepsis.

Sodium Salts.

Miss G.J., aged 17, presented on 24.9.36 for removal of a buried and impacted $\overline{8}$ which was septic, swollen, and painful. She had numerous pimples on head and neck and a large dry sore on the chin. The complexion was colourless and the gums were very pale. Saliva pH was 7.2. As a precautionary measure patient was advised to take bicarbonate of soda. One week later the wisdom tooth had settled down, patient looked and felt better, the pimples had almost disappeared and the spot on the chin was considerably smaller. $\overline{8}$ was then surgically removed under a nerve block and patient was advised to continue taking the powder. A week later, when seen again for removal of sutures, patient looked quite fit, spots had completely disappeared, and she reported that she had had no pain whatsoever from the operation, which is remarkable in view of the usual sequelæ of bone removal. In this case the upset causing distress was obviously a dehydration in spite of the high pH of the saliva. It also illustrates the necessity of clinical findings.

Gwendoline Jessett

Case No. 10

**Sepsis of Compound Fracture Manganese, Iron and
after Wiring. Mixed Alkalis.**

The patient, a female aged 3½, was brought for examination because the mother thought “the lower jaw was crooked”. There was a history of an accident about two months previously, which resulted in a fractured collarbone and sundry bruises and skin abrasions. These had been treated, but unfortunately the jaw was not diagnosed, as several X-rays had not shown any apparent defect. On examination, it was clear that the fracture of the lower jaw was more a tear of the symphysis than a true fracture.

Further X-rays locally showed the parts to lie separated by over an eighth of an inch. Some sepsis was present, as denoted by fistulæ on the gum and below the chin. All temporary teeth were erupted with the exception of \overline{a} , which had obviously been knocked out at the time of accident. \overline{a} was loose. A metal cap splint was made and cemented to the teeth. Unfortunately this did not stay in position. A second attempt to fix it was also unsuccessful. Arrangements were accordingly made to wire the bone. This was done on 21.5.37.

Progress of the wound was extremely slow, as it commenced to suppurate soon afterwards, and the general condition of the patient became gradually worse. On 28.5.37 it was decided to try general treatment in an attempt to improve the condition. Accordingly she was given half a tablet of nutritive salts daily, together with Crookes colossal manganese and ferromalt. Within a week the sepsis was almost eliminated and pus no longer was apparent. Ten days were sufficient to enable patient to be discharged from the wards. From then healing progressed uneventfully.

Case No. 11

Neuritis.

Halogen Salts.

Mr R.E.T. presented on 4.6.36 for treatment of pyorrhœa. He also complained of a severe neuritis in the right arm. which treatment had not alleviated. The teeth were fairly firm, gums were swollen, with a purple line about the margins and a fair amount of subgingival tartar. His health had been excellent till about 1916, when he was wounded several times. From one of these he contracted blood-poisoning in his right hand in 1917. In 1931 he had a tonsillectomy performed to relieve neuritis, without avail. His bowels were regular (?). His father was also rheumatic.

His pH was 7.1 and his blood picture showed large numbers of particles moving, mostly giant in size. There were many

small clumps moving and precipitated with small particles adhering to some of the corpuscles. The patient was instructed to brush his gums with an arsenical paste and given mixed halogen salts of magnesium t.i.d. When next seen. ten days later, his, neuritis had practically gone and his gums were greatly improved.

This case shows how the familial tendency to rheumatism was precipitated by a war wound, and the patient continued to suffer for many years till the effects of hydration were eliminated from his blood-stream.

Case No. 12

Migraine.

Halogen Salts.

Mrs M.S., aged about 45, sought dental advice as, having had treatment for her frequent headaches over a long period without avail, thought her teeth might be the cause. When seen on 10.10.35 the saliva pH was 7.3. The gums were reddish-blue and inflamed. There were several deep pockets and several teeth were loose. As the patient was moving to another town she did not wish for extensive operative procedure if it could be avoided. Two very septic teeth were removed and a scaling done, and patient was advised to massage with a preparation containing arsenobenzine. She was put on a course of mixed halogen salts internally. Five weeks later a letter was received from the patient from which the following is an extract:

“I want to say what a wonderful thing your treatment is. I have gone through one of the most gruelling times of my life, and I’ve had some pretty bad ones, and migraine has not attacked me till last week and then only a slight attack. I am most grateful for it.”

Here it is evident that the colloidal complex was disturbed by a chronic hydration, which was easily corrected.

*Case No. 13***Asthma.**

Mrs A.H., aged 38, presented in the hope that the removal of her remaining teeth would clear up her general symptoms. She had been suffering from severe asthmatic attacks, which were liable to occur every few hours. No treatment had proved of any use, and she got slight relief by giving herself frequent injections of adrenalin. Her history told that she was anæmic twenty years ago, which improved on marriage. She had had three children, of whom two were boys, aged 19 and 9. Thirteen years previous to consultation a laparotomy was performed. Four years ago a female foetus was born prematurely, and when three weeks old was badly burnt and succumbed to her injuries. The mother was in hospital as a result of the same accident and with a leg injury which turned septic. While an in-patient her asthma commenced and had continued ever since, and is now accentuated by even the slightest exertion. Her saliva pH was 7.4. Her blood picture showed a few particles moving, which were mostly large. A few refractile large particles were precipitated. Her doctor states that her case "is chronic and he can find no organic reason for her symptoms." The patient declined to undergo any form of general treatment in which she had no faith. Although it is certain that a course of dehydration with halogen salts would have ameliorated the condition, the patient was rather upset at a reluctance to remove her few remaining teeth, which were comparatively sound.

*Alice Hemminghaw**Case No. 14***Persistent Styes.****Sodium Salts.**

The patient, Nurse A., had frequent headaches for about two years, and recently had an operation on her antra (maxillary and mastoid). Previously and subsequently she had almost continuous discomfort from styes in the eyes. She recently had a very severe reaction from anti-scarlatina vaccine.

On 24.7.36 X-ray examination showed both lower wisdoms with thickened periodontal membrane, but as the patient was only 21 years old this may not have had any significance. The upper right canine was root-filled but showed no sign of apical infection. Her pH was 6.8 changing to 7.2 on resting. Refractive index of the serum was 1.3494. Blood sugar was 0.077. The ultramicroscopic picture of the serum showed large sheets of small precipitated particles, a large number of moving particles of varying sizes, and some were large and refractile. Blood corpuscles were crenated and many had particles attached. In this case the saliva suggested an alkalosis, whereas the real state was, a severe hydration. Blood corpuscles have, when oxygenated, a negative charge which would attract the positively charged particles in the serum. The treatment advised was large doses of sodium bicarbonate, which in three days cleared up the styes, and these had not reappeared in nearly three months. Unfortunately, her doctor discontinued the sodium bicarbonate as it made her vomit (which difficulty would probably have been overcome by reduction of the dose), so no doubt there would be a recurrence of the symptoms at a later date. Really she should have continued the treatment for a sufficiently long time to bring her blood picture to normal, but the doctor could not see any need for further treatment once the symptoms had cleared.

Case No. 15

Ulcerative Stomatitis.

Nutritive Salts.

Mr S., aged 16. presented on 26.11.36 for treatment of a severe ulcerative gingivitis. The gums were inflamed generally. The lower incisors were stripped for more than half their length. The margins of the gums were red, ulcerated, and swollen, bleeding easily on the slightest pressure. Patient had a thin layer of hard black tartar all over labial and lingual surfaces of teeth. His face was dry and scaly, and he looked pale and anæmic.

The blood picture showed very few particles moving, and a large number of small particles were precipitated on slide. numbers of corpuscle casts and pseudo-spirochætes were visible. Treatment consisted of nutritive salts, 2 tablets per diem, and gum massage with arsenical preparations. When seen again on 11.12.36 the patient's skin was clear and soft, the gum condition had almost completely disappeared, and the incisors were covered to normal distance with gum tissue. Patient also reported feeling much better in health.

The blood picture showed a fair number of particles moving, both small and medium. There were still a number of precipitated particles which were much larger than previously. No pseudo-spirochætes. As a prophylactic measure patient was advised to continue nutritive salts for a month and be careful about his mouth hygiene in future.

Case No. 16

Post-Operative Sepsis. S.U.P. 36 and Halogen Salts.

Mrs E. S., a stout, septic-looking woman, aged 44, attended hospital on 25.6.36 for pain in the lower wisdom region. Her gums were a deep purple and heavily infected. The saliva pH was 6-1.

The blood picture showed sheets of gelated particles. There were only a few particles moving, and these were mostly small and medium in size. The blood corpuscles had particles attached.

Pain had been present for a week or two, and as she had difficulty in getting time off work, two lower impacted wisdoms were surgically removed under nerve blocks at one sitting. The patient was instructed as to the usual post-operative procedure, which unfortunately she neglected. Later she called in her doctor, who treated by the simple but not too effective expedient of putting her to bed. About ten days later, when she returned for examination, her face on one side was considerably

swollen and very painful, her jaw was practically fixed, and she could only take only liquid nourishment. She was given a subcutaneous injection of 1 c.c. of S.U.P.-36 and instructed to take a teaspoonful of sodium bicarbonate each morning in water. When seen five days later the swelling was considerably reduced. She was able to move her jaw freely, and could take solid nourishment with just a little difficulty. She had slept well, and pain had practically vanished since the injection. The sutures which could now be seen were removed, and she was put on a course of treatment consisting of mixed halogen salts of magnesium. Three days later her gums were in fairly good condition and a scaling was done. A week later the patient reported feeling better than she had done for years—she had lost about a stone of superfluous fat and her gums were quite normal. This case is of particular interest in showing how a hydrated patient with pyorrhœa becomes septic from an impaction; dehydration supervening on hydration. The former being corrected, then the hydration was treated. The remarkable point was the cure of the gum condition in so short a time without any local treatment to gums.

Case No. 17

Vincent's Angina.

Trivalent Arsenic.

The patient, Mr W.L., had been attending out-patients' department of hospital for a huge swelling in the right parotid area, which was diagnosed as calculus in the duct. X-rays showed most of the teeth to be septic. After about two months he was admitted to the ward, for observation and treatment: a lower right wisdom root was removed under N₂O. Anæsthesia was very difficult and followed by much pain.

When seen by the author on 23.6.36 he had a light Vincent's infection with the typical foul odour from his mouth, his gums were red and inflamed, with considerable sloughing in the area of extraction. His saliva pH was 6.0. His blood picture

showed a decreased number of particles, small and medium. The Brownian movement was sluggish, and small particles were precipitated on the blood corpuscles. A number of precipitated particles and casts of corpuscle envelopes were present.

Two injections of 0.05 gramme of sulphostab were given. The small dose was given in error by the house surgeon, and resulted in a flare-up, which was operated on externally on the fifth day by the Hilton method. Two days later the patient was again seen, when his blood picture was still bad. There were a moderate number of medium-sized particles, movement was fair to sluggish, with a number of precipitated particles, blood corpuscles had particles attached and some were crenated. The dose was corrected and he then had two injections of 0.3 gramme at three-days' interval. His temperature dropped immediately after the first injection, and swelling diminished in a few days. A week later his mouth was cleared under ether, about 25 teeth and roots being removed and all septic sockets curetted. The anæsthesia was perfect, patient was quiet and well-behaved. There was profuse bleeding during the operation, which stopped completely within a few minutes. In fact, a short time afterwards his sockets looked as if they had been clotted for several hours.

A week later his blood picture showed plenty of moving particles of fair size, some precipitated on the glass, no precipitated masses or sheets could be seen. Patient had no discomfort or pain after this extensive operation, which is a surprising result in such a short time. The treatment was completed with a strong strychnine tonic for about six weeks.

This case is one of severe dehydration present over a considerable period. It should be obvious that the Hilton operation did very little in correcting the patient's condition: as a general rule the results of this operation are slow.

*Case No. 18***Lymphatic Leukæmia.**

12.1.37, A.C.F., a schoolboy aged 14, was admitted to hospital with considerable swelling over the left angle of jaw, which had been present about five days. He looked very pale, thin, and anæmic. Oral examination disclosed a large gangrenous ulcerating slough, spreading out into the palate, which covered about the area of a shilling piece. Several teeth were carious and the mouth was very dirty. The gums were hypertrophied and in places almost covered the teeth. There was a copious discharge of pus and a foul odour. The patient was given warm peroxide washes frequently in order to clean up the local condition. When seen twenty-four hours later the mouth condition was cleaner but still very bad.

A swab from the gums showed many and various organisms—but no Vincent's. A culture gave a growth of non-hæmolytic streptococcus. The Wasserman reaction proved negative. On pricking the finger to obtain some blood, the tiny would spurted like a fountain for a second or two. The blood picture showed an increased surface tension. There were few particles moving, most of which were small and sluggish. A number of tiny particles precipitated on slide. In fact there was evidence of a severe dehydration. In contrast to the usual Vincent's picture there were no large particles to be seen. A piece of the slough was dissected away, and when examined showed no trace of cellular formation.

X-ray examination showed few abnormalities, except for a number of carious and septic teeth. There was little bone change of note.

The treatment prescribed consisted of sulphostab in 0.3 gramme doses by injection. It was decided to postpone operative procedure for about a week until the patient's local and general condition had improved. However, after three injections had little if any effect upon the general condition, a

more serious state of affairs was suspected. The blood count was typical of lymphatic leukæmia:

Erythrocytes	2,200,00 per cu. mm.
Leucocytes	42,300 " " "

A stained specimen showed these latter to be 100 per cent. lymphocytes and lymphoblasts with no polymorphs. The hæmoglobin was 34 per cent. and colour 0.77.

This suggested the condition to be hopeless. On 20.1.37 the temperature was swinging up to 103. The slough on palate was cleaner but now spreading on to the lower jaw. On 23.1.37 the glandular swelling in the neck was increasing. Tonsils were large and almost meeting. The left eye was puffed up.

24.1.37. There was an increase of general pallor, with cyanosis of eyes. The fungating mass on left side of upper jaw was extending. There were no petichiaë and no enlarged glands in neck. The spleen could not be felt, although it seemed to be enlarged on percussion. The liver seemed about normal. Patient was rapidly becoming œdematous about face and neck. There was no albumin or acetone in the urine. The condition rapidly progressed to a fatal issue two days later.

The post-mortem findings showed the spleen to be about double normal size, The mesenteric glands were uniformly enlarged to about the size of a pea. There were petechial hæmorrhages under visceral pericardium. The glands in the upper part of neck were enlarged.

This case is recorded because the comparative rarity of this condition makes it one of interest. There is apparently no known cure or cause of this disease, and its progress is as a rule fairly constant, An attempt was made to administer alkalis of various sorts, but owing to the patient's unwillingness to take any medication the amounts retained were useless. In any case, had medication been successful it is doubtful if it would have done much more than prolong life for a short time.

*Case No. 19***Squamous Cell Epithelioma. Effect of Radium and Deep X-ray Therapy.**

This case is reported to show the effect of intensive ray therapy and its ionising effect on the chemical constituents of the blood. The patient, Miss B. S., aged 29, came under observation direct from intensive treatment with radium bomb and deep X-ray therapy. The epithelioma of squamous-cell type had recurred somewhere at the back of the nose and was of indefinite limits. Previous treatment had not been so drastic, and the condition had relapsed on several occasions. The intensive treatment recently undergone had caused an erythema of the head and neck, the lips were dry and cracked. The gums appeared normal, but were pale and anæmic-looking. There was little caries formation. Unfortunately the serum was not examined previous to treatment, but a few days subsequently it presented the most active picture imaginable. There were myriads of intensely active particles of varying size. The corpuscles and other particles all seemed to radiate activity. A number of crystals similar to those found in colloidal calcium appeared in a short time in many and varied shapes. These all seemed to radiate emanations of some sort.

B. Sykes

When the blood was examined, after standing in a tube on the work bench for about a week, it was found to have lost all trace of the intense activity, and particles had decreased in number and increased in size. A number were very refractile and had distinct capsules about them. In fact there was evidence of marked hydration and no sign whatsoever of dehydration.

The probability is that the radio-active treatment had rendered the chemical constituents of the blood temporarily radio-active, and the effect of this passing off probably caused a reversion of the colloidal system to the state of hydration in which it had been before administration of rays.

*Case No. 20***Evipan Anaesthesia Showing Effect on Particles.**

The patient, Mr R.R., aged 37, a smallholder, presented on 4.3.37 for the extraction of three broken-down teeth which were causing considerable pain. His previous history told of pneumonia in 1910, malaria and blackwater fever about 1920 in Africa. For the last two years he had been in constant ill health, with numerous attacks of malaria, influenza, colds, bronchitis, and ague, which usually tended to settle in the chest. He was suspected of T.B., but all tests proved negative. He was subject to considerable gastric disturbances. His gums were pale and pocketed and there was a "sick" smell from the breath. His skin was damp, sallow, and septic-looking.

His pH was below 6 and his blood picture showed a fair number of particles moving, which were mostly small and medium in size. An occasional moving large particle could be seen. These had a tendency to agglutinate with others. There were a few precipitations. Numerous pseudo-spirochaetes were visible, some of which were 15 μ long. The blood corpuscles were small and very refractile. Their shapes seemed to vary as if the envelopes were flexible. There were a few ringed particles which were very tiny.

In view of the surgical difficulties, evipan was administered. A specimen of his blood while under the anaesthetic now showed few particles moving. There were a large number of small particles precipitated on the slide in sheets. A number of bright refractile particles were precipitated, some were ringed and others were red in colour. This, picture, which was obtained from two specimens of blood taken from the same patient within a few minutes, should be sufficient to illustrate the strong hydrating effect of evipan sodium combined in all probability with some preliminary dehydration. It also illustrates the possible dangers of that substance if the patient is

already subject to an advanced degree of hydration.

Subsequently the patient was put on bicarbonate of soda, and a few weeks later he looked and felt better in general health. His gastric symptoms had disappeared but his chest was still liable to trouble him.

CHAPTER XVII

PLUS AND MINUS

Having outlined the foundations of electrionic medicine, and traced the development of modern atomic ideas in their relationship to dental health, it now becomes necessary to round off the whole matter with a brief recapitulation of certain facts so that the reader will be encouraged to follow on the path of exploration already indicated.

Let us therefore tabulate a few more obvious opposites along the lines laid down by Aristotle so many years ago. This should indicate how our lives are intimately composed of joys and sorrows, which mingle together in this our chequered existence. These opposites are not in any degree equal to each other, but they help to point out the comparative excesses and defects which must constantly alternate to keep a relative balance of dynamic power or vital force in our lives.

Defect	Excess
Acid.	Alkali.
Disintegration.	Condensation.
Dehydration.	Hydration.
Sympathetic dominant.	Parasympathetic dominant.
Reducers.	Oxidisers.
Positron.	Electron.
Hot.	Cold.
Infra-red.	Ultra violet
Non-metals	Metals.
Female.	Metals.
Night.	Day.

The combined importance of these opposite factors should now be obvious to the reader, especially those at the beginning

of the list. From hot and cold down, however, they may not be quite so clear. Any substance which is hot tends to loose heat energy; that which is cold will tend to gain heat. The terms are relative and depend to a great extent on environment. Heat tends to loosen or expand atomic construction by activating it, cold tends to act in the different direction. Infra-red therapy should be of more use in cases of chronic disease or hydration and ultra-violet on the other hand should greatly assist cases of dehydration — two interesting speculations in connection with ray therapy which might assist in explaining certain failures with these instruments of medical science.

Non-metals and metals are easily placed if reference is made to the Periodic Table (fig. 4). It would then appear that those elements towards the left hand of the table tend to radiate or donate activity in chemical reactions; whereas those towards the right hand tend to absorb or acquire it. This directional tendency of electron movement, and of energy quanta also, is probably the basis of health. The opposing forces must be in such a balance as to be constantly dynamic; if a strong throw-over occurs to either side there is a tendency to become static and the free interchange of energy necessary to correct biological function becomes impaired. Metals therefore tend to radiate or donate activity whilst non-metals tend to attract it. The action is similar but not quite the same as the power of an alkali to donate electrons and the acid to acquire same.

Female and male in their sexual characters also display that same reciprocal arrangement. Nan de Velde (1929) states that the normal genital secretions of the female are distinctly acid in character, whereas the male secretions are alkaline. The receptiveness of the female compared with the ejaculation of the male in the sex act is almost on a parallel with the properties of certain atoms and their electrons which have already been pointed out by Kendal (1929)

Night and day also denote the two opposing characteristics. compare the relative inactivity of the former with the hustle of the day. Nature demands alternation and a harmonious but dynamic blend of opposing characteristics. So much for the principles involved. What is then the cause of finding so many conditions in human life to-day which indicate a disturbance of the equilibrium of these two forces? The balance lost, disease becomes rampant. Disease is, of course, the outward and visible sign of this disequilibrium of the vital forces.

The memorandum recently issued by the three British dental organisations to the Ministry of Health states that “the number of accepted recruits who required dental treatment in the Navy was 96.8 per cent. ... in the Army 98 per cent.” It also draws attention to the fact of the following diseases “being attributed to or aggravated by defective teeth: (a) Anæmia, (b) Gastric trouble, (c) Debility, (d) Tonsillitis, (e) Neurasthenia, (f) Rheumatism.” (See Dental Gazette, June, 1937, page 615.)

These statements, which are well founded on the basis of reputable statistics and considered opinion, seem to link up with the story told in the foregoing pages in a remarkable manner. From this it can be seen that the great majority of persons examined, and probably also those of the rest of the population of these islands, are suffering or have suffered from a deficiency of electrionic energy, acidity, or (dehydration which destroys the normal structure of their live, with a tendency to physical upsets.

The other interesting point which evolves from this memorandum is that the group of diseases which are “attributed to or aggravated by” dental trouble are the same group of conditions which can be caused by a defective electrionic content of the serum. It does not seem unreasonable, therefore, to state here most emphatically that this is not so much a question of being “attributed to or aggravated by” but that dental disease and the other enumerated diseases have a common origin in the

primary upset in the colloidal chemistry of the nation's blood.

This upset may be brought about by many and diverse conditions. The next thing to do would naturally be to lay down some sort of scheme of living which would tend to eliminate this distress, and render the health of the nation Al.

To do this would occupy too much time and space. However, a few general principles will not be out of place. Primarily the upset is brought about by our modern life being unnatural in certain respects. The people to-day are educated to live fast. Life is hurry and bustle — rest is something to be indulged in as quickly as possible. Complete relaxation is almost a lost art. From this it is obvious that the energy reserves of the people are being steadily reduced from generation to generation. The time necessary for recuperation and regeneration is grudgingly allocated and often inadequately used.

The other part of the equation, the food or energy intake, is inadequate. Foods are artificially prepared. Modern cooking tends to demineralise and take the energy quanta away from the products tendered at table. Good old-fashioned cooking has been replaced by that modern scourge, the open gas flame. The old way of cooking in a closed container or oven preserved the natural energy in the food. This to-day can still be employed by the coal oven or electric cooker. The gas fire obtains its energy by the combustion of gases; the transmutation of chemical energy into heat results in a large quantity of ionised gas which is mostly hydrogen. Ionised hydrogen is, as has been pointed out, a powerful acid and consequently will tend to acidify the food cooked in such an atmosphere. The simplest test is easily applied by tasting meat cooked by the two methods, and the palate will soon give the correct answer.

Prolonged boiling of vegetables is another potent source of deficiency. The smaller atomic salts are those which are the first to dissolve. and are those most necessary for the

maintenance of alkalinity or energy content in the body. Frequently they go down the sink to the sea. Vitamins are also probably destroyed to some extent by over-cooking.

The cure is obvious — more natural ways of living are best; but if that is not possible, the next best thing is an increased intake of mixed alkalising compounds as an addition to the daily diet. Care must be used of course in connection with this statement, as some persons may be in a state of balance, where the addition of large amounts of alkali will do more harm than good — but every medical and dental man who cares to think and experiment along the lines laid down in this thesis will soon find the right treatment for the conditions which present themselves for his considered attention.

In conclusion it is hoped that the reader, having borne patiently until now, will adapt at least some of the ideas contained herein to his own practice, and by recording his results will help to build another branch of the healing profession and one which outlines the basic principles of Health and Disease.

BIBLIOGRAPHY

- ALEXANDER, J.E. (1928). *Colloid Chemistry*, Chapman & Hall.
- BAINBRIDGE, F.A., and MENZIES, J.A. (1920). *Essentials of Physiology*, Longmans, Green.
- BAKER, E.A. (1932). *New English Dictionary*, Oldhams.
- BECHOLD, H. (1920). *Colloids in Biology and Medicine*, Van Nostrand.
- BIGGER, J.W. (1937), *Handbook of Bacteriology*, Baillière, Tindall & Cox.
- BILHAM, P. (1937). "pH", *Brit. D. J.*, Jan. 1.
- BRODERICK, F.W. (1936). "Diathesis as a Factor in the Aetiology of Disease". *Brit. D. J.*, Jan. 1.
- BRODERICK, F.W. (1936). *The Principles of Dental Medicine*. Second Edition. Kimpton.
- COCKING, T.T. "pH Values," British Drug Houses leaflet.
- COHEN, J. B. (1926). *Practical Organic Chemistry*, Macmillan.
- COPE, C.L. (1936.) "Alkali Poisoning", *Brit M. J.*, Nov. 7.
- FISHER, D. 1926). *Sur., Gynec., and Obst.* (Aug.), 43, 224,
- FISK, D. (1936). *Modern Alchemy*, Faber & Faber.
- GORTNER and HOFFMAN (1921). *J. Amer. Chem. Soc.*, 43, 2199.
- GREEN, A.C. (1934). "Intravenous HCl", *Brit. M.J.*, Apr. 21, p.739.
- INFIELD, L. (1934). *The World of Modern Science*, Gollancz.
- KENDAL, J, (1929). *At home among the Atoms*, Bell.
- KRÆMER, E.O. Studies with the Kinoultra-microscope," *Colloid Symposium Monograph* (Chemical Catalog. Co. Inc., N.Y.).
- LEVY (1926). *Am. J. Obst. and Gynec.*, Dec 12, 866.
- McDONAGH, J.E.R. (1926). *Nature of Disease*, Vol. I., Heinemann.
- McDONAGH, J.E.R. (1927). *Nature of Disease*, Vol. II., Heinemann.
- McDONAGH, J.E.R. (1931). *Nature of Disease*, Vol. III., Heinemann.
- McDONAGH, J.E.R. (1932). *Nature of Disease Journal*, Vol. I., Heinemann.
- McDONAGH, J.E.R. (1933). *Nature of Disease Journal*, Vol. II.,

Heinemann.

McDONAGH, J.E.R. (1934). *Nature of Disease Journal*, Vol. III., Heinemann.

McDONAGH, J.E.R. (1936). *The Common Cold and Influenza*, Heinemann.

MacLEAN, H., (1922) *Modern Methods in the Diagnosis and Treatment of Glycosuria and Diabetes*, Constable.

MacLEAN, H., (1922) *Modern Methods in the Diagnosis and Treatment of Renal Diseases*. Constable.

MacLEAN, H. "Method for the Estimation of Blood Sugar," British Drug Houses leaflet.

MEE, A.J. (1934). , Heinemann.

MITCHELL. R.F. (1930). *J. Soc. Motion Picture Engineers*. U.S.A., XV, 5, 679.

NOUY., LECOMPTE DU (1936) *Biological Time*, Methuen.

PARTINGTON. J.R. (1930). *Text-book of Inorganic Chemistry*, Macmillan.

RANDALL, J. (1937). "Luminescence and its Application", *J. Roy. Soc. Arts* (March 5), LXXV. 4398.

RAYMOND, M. (1934). "One of Life's Greatest Mysteries", *Daily Express*, April 20.

ROSTOCK, P. (1929). "The Importance of Refractometry in Clinical Research", *Ind. Med. Gaz.* (Oct.).

SCHAFFER, E. S. (1920). *Essentials of Histology*, Longmans. Green.

SODDY, F. (1932). *Interpretation of the Atom*, Murray.

STARLING, E.H. (1930). *Principles of Human Physiology*, Churchill.

TORRENS, R.G. (1930). "Simple Extraction of Difficult Teeth." *Brit. D. J.*, Mar. 16.

TORRENS, R.G. (1937). "Dental Medicine versus Dental Surgery," *Brit. D. J.*, Jan. 15.

TORRENS, R.G. (1938). "Protein. Particles and Dental Disease", *Dental Delineator*, June.

VELDE, T.H. VAN DE (1939). *Ideal Marriage*, Heinemann.

WELLS. P.E. (1919) *J. Wash. Acad. Sci.*, quoted by Alexander (1928).

ZSIGMONDY, R. (1909). *Colloids and the Ultra-microscope*, Wiley.

RECOMMENDED BOOKS

On many occasions interested persons have inquired what books to read in order to study the subject dealt with in this book. For those so interested the following recommendations are given. This list will form a good groundwork for study. Further volumes will suggest themselves as the student progresses.

Text-book of Inorganic Chemistry, by J.R.Partington. 1930, Macmillan.

At home among the Atoms, by James K. 1929, Bell

The World of Science, by F. Sherwood Taylor. 1936, Heinemann.

The World in Modern Science, by Leopold Infield. Translated by Louis Infield. 1934, Gollanez.

Modern Alchemy, by Dorothy Fisk. 1936, Faber & Faber.

Revolution in Physics, by Ernst Zimmer. 1936, Faber & Faber.

Colloid Chemistry, by E.J. Alexander. 1928, Chapman & Nall.

Dental Medicine, by F. W. Broderick. 1936, Henry Kimpton.

Nature of Disease, Vols. 1., II., and III., 1927. 1927 and 1931.

Nature of disease Journal, Vols. I., II., III., and *The Common Cold and Influenza*, all by J.E.R. McDonagh. Heinemann.

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