Zoo Chemistry.

Proximate Principles.

A Proximate Principle is any substance, whether simple or compound that exists under its own form in the animal solid or fluid; and can be extracted without altering its chemical composition & properties.

These exist in all parts of the animal economy and make up its substance by their combinations, and are divided into three general classes.

The first comprises all those which are purely inorganic in their nature; they are derived almost wholy from without and exist in the animal, in the same chemical form as elswhere and have a deffinite chemical composition and are chrystalizable.

They comprise water, Chloride of Sodium, Chloride of Potassium, Phosphate of Lime, Carbonate of Lime, Carbonate of Soda, Carbonate of Potassa, and Phosphate of Magnesia, Soda and Potassa.

The second class are chrystalizable substances of organic origen and have a deffinite chemical organization. They are called organic because they first make their appearance in organized structures, and are not found in the inorganic kingdom. They comprise the different kinds of sugars, oils, starches, and further distinguished by being composed wholy of C. H. O. being entirly destitute of Nitrogen.

The third class comprises a very extensive and important order, and are known as Organic substances proper, or Albuminous substances, or again as Protein Compounds.

This class of proximate principles are in every respect peculiar, not being found except in living, or recently dead animals and vegetables.

They have not a deffinite chemical composition, and are not chrystalizable and the changes which they undergo in the animal econemy cannot be expressed in ordinary chemical phraseology. This class includes such substances as Albumin, Fibrin, Casin, and the distinct ive principles of all the animal solids and fluids, and go to make up a large portion of its entire bulk. They are further distinguished from the second class by the fact that they always contain, in addition to Carbon, H & O. a fourth ingredient Nitrogen, and on this account are often termed nitrogenous substances, some of them also contain a small amount of Sulphur.

The first class of proximate principles pervade the entire animal organism, and several of them are found in almost every solid and fluid we meet with.

Water is one that is universal and very abundant, making up the great bulk of all fluids, and a very large proportion of the solids.

Siliva contains ,995 of water in 1000 parts
Presperation " ,986 " " " " "
Gastric Juice " ,975 " " " " "
Pancreatic " " ,900 " " " " "
Bile " ,880 " " " " "
Blood " ,795 " " " " "

Brain	contains	.789	of	water.
Mussels	"	.750	"	"
Bones	"	.130	"	"
Teeth	"	.100	"	"

According to the best calculation the human body contains nearly three fourths of its weight of water, which is derived wholy from without. It is taken in the different forms of drink, and is very abundant in the different forms of solid food. We use no food that is absolutly dry, and it is not always easy to ascertain the exact amount of water it contains, but it is supposed that a healthy man will usualy take

between four and five lbs. per day.
It is used to form a part of all the fluids and solids without exception, and plays an important part in the physical and chemical changes of the organism, and is again discharged always carrying with it a considerable amount of other wornout and effete matter. Its presence in the body is never permanent, but alwas changing like every other proximate principle.

Cloride of Sodium also pervades the structure of the body except the enamel of the teeth. Its presence is considered very important in regulating the phenomenon of endosmosis and exosmosis in the formation of different fluids and structures of the body, though it must not be supposed that these functions could not be performed without it. Like water it is derived wholy from without, and a portion is lost or rather decomposed into other salts, so that it is not excreted as abundantly as it is supplied.

Salts therefore become an important ingredient of our food, and is added to it or taken seperatly. It occurs in all animal food in the proper quantity, so that addition is unnecessary, but vegetables do not contain a suf-

ficient quantity, so that all herbivo-
rous and gramminivorous animals seek
it as a seperate article of diet. These
it is true will live with that which
they obtain with the grass they eat,
but experiments prove that they will
be more robust an lively with a small
quantity of salt in addition.

Phosphate of Lime next to the
Cloride of Sodium is the most im-
portant salt contained in the ani-
mal body, and is the most abund-
ant of the mineral substances.
Like the water it pervades every struc-
ture of the body and is present
in all its fluids.

The enamel of the teeth is formed almost wholy of it, while it constitutes more than half the weight of the bones. It also occurs under very different physical conditions, in the bones it is solid, not as a powder, or in chrystals, but intimatly connected or compounded with other substances to give the characteristic bony structure.

While in the blood it is in a fluid condition, held in solution by the albumen, which in turn is held in solution by the water in which the phosphate is not soluble. It is therefore united with other principles of the body so as to loose for the time its inorganic characteristics. Its use in the solid parts such as the bones, cartalage, &c, is to give them stifness and strength, so that they may overcome resistance, and the body retain its simetry.

From the bones it may be removed by a weak solution of Muriatic acid, leaving the other ingredients in tact, when the bone may be bent to any shape without being broken.

Most of the other proximate principles of this class are present in each every substance of the animal frame, and its fluids though generaly in small and varying proportions, it is not necessary to run over them particularly, for none of them seem to perform any especial function which can be clearly demonstrated.

The proximate principles of the second class comprise the different sugars, oils, and starches all of which you have studied, and fully understand their composition and from whence they come. Their connection with or uses in the animal economy, will be fully considered in connection with digestion, and need not be spoken of at any extent here.

The third class comprises a large order of very important substances, most of which are not found any where but in the animal kingdom. They, with the water they hold in combination, form the great mass of every portion of the body both solid and fluid, except the bones, and even in these they are next in abundance to the Phosphate of Lime.

Somtimes they exist as fluids, as in the albumin of the blood Pepsin of the Gastric Juice, again as a semisolid as in Musculine of Mussels or the of the blood, or again in the solid form as in the bones.

The most important peculiarity in the chemical sense is their want of a deffinite chemical constitution. All those substances we have heretofore studied have had a deffinite and fixed proportion or ratio between the different simples of which they are made up, which cannot be changed in the slightest degree whithout the decomposition and distruction of the charactor of the substances.

With these organic substances this law seems to have lost its rigor, and the substances belonging to it continue to exist without any apparent change of properties or other modification, though their atomic constitution be inconstant or vary within certain limits. This is especialy characteristic of this class of substances. The Albumin which is composed of C. H. O. N. & S forming the principle part of the eggs you eat, gives a portion of its Sulphur to combine with the silver of your spoon and blacken it, without itself being injured or changed, while the Phosphate of Lime cannot loose any portion of an equivolent of Oxigen without being distroyed.

The Fibrin of the blood may vary in its number of equivolents and yet remain truly fibrin, while the slightest change in the equivolents of Chloride of Sodium utterly distroys it. The substances of this class therefore do not loose their character or even suffer practical change, though they may contain a few equivolents more or less of one or more of the ultimate constituents. This is the probable reason of another equaly curious fact.

Although they will unite with either acids or bases, they do not play the part of either acids or bases in such compounds for the Acid or alkaline qualities is not neutralized by them but remains as strong as if uncombined, neither does the union take place in any deffinite proportions but generaly in all proportions, so that these substances have no combining equivolents. They all, as before said, contain C.H. O.N. but a few of them contain a small proportion of Sulphur and Phosphorus, and with these exceptions, the proportions of the elements they contain is very similar.

Fibrin contains about $C_{298} H_{228} N_{40} O_{92} S_{2}$.

Albumen " " $C_{216} H_{196} N_{27} O_{68} S_{2}$.

Casein. " " $C_{288} H_{228} N_{36} O_{90} S_{2}$

Others are similar to these, except that they contain no Sulphur. On account of their variation formulas are not generly given or even considered important.

Thes substances are all Hygroscopic, that is they contain a large amount of water in ~~the~~ composition which may be removed by evaporization without distroying them and then if they be again exposed to water they will absorb and regain their former consistence and properties.

This water may be deminished by lack of supply, within certain bounds, and still not interfere with the functions, this is also true of all the constituents, so that a small lack of this or that principle in the food we take borne without injury, which could not well be the case if their constitution was rigidly deffinite as in the organic kingdom. This is an all wise provision of which you will all see the force in a moment.

If it were otherwise, if these substances required exactness as compounds of the inorganic world, the slightest lack of any one of the constituents in our food would distroy the whole fabric.

Another important characteristic of organic substances is that they readily excite in other proximate principles or in each other catalitic transformations. That is, they produce changes not by combining with the substances altred or any part of it, but simply by their presence. Thus the organic principle of the intestinal juice converts starch into sugar, without undergoing any change in its own constitution or functions. The Albumen of the blood by contact with the proximate principle of the muscular fiber, is converted into a substance similar to it. The entire process of nutrition, so far an organic substances are concerned, are carried on by these Catalitic transformations.

Still another peculiarity of these bodies is their coagulation, that is those which are naturaly fluid under certain conditions, sudenly become solids or semisolids. Thus when Blood is drawn the Fibrin coagulates, and the jelly like clot is formed, or the Albumen of lean meat, by the temperature of boiling water, or again the Casein of Milk by contact with an acid by which the milk is clabered.

Finaly the organic substances are the only ones capable of Putrifaction. This process is a very complicated one and is characterized by a gradual liquifaction of the whole substance and the generation of very disagreable gasses among which are Sulphuretted, Phosphuretted, and Carbonated Hydrogens, Carbonic acid, Nitrogen, and Amonia. Putrifaction commences almost immediatly after death, if the body be exposed to a moderatly warm temperature, in a moist atmosphere.

Nearly every animal fluid and

tissue contains one or more proximate principles, which is peculiar to itself and is found no where else. Much the same as plants and shrubs, which you have already studied, have their own peculiar essential oils.

Many of these will be spoken of more deffinitly, when we consider the fluids and tissues of which they form a part.

The Animal Frame.

When we come to examine the Carcas of any of the higher order of animals we are led first to consider the basis or solid structure upon which it is built; and afterward the different organs of the economy.

The skeleton may be said to be the foundation upon which the structure rests; and by it the various organs are supported, while a system of mussels attached to the bony structurs, by their contractions and extensions, convert the long bones into levers, by which means the body is moved about from one place to another. With this matter we have little to do at this time.

We have however enclosed in this great system of bones and muscels, another system of organs, each of which is in and of itself a chemical labratory, and each has a contract for a certain amount of a certain kind of chemical work to perform in each twenty four hours; and if any one of these workshops fail to turn out the proper amount of properly wrought material, then the whole economy is deranged and disorder and desease is the result.

The material upon which the organs depend for their supplies, comes originaly from without the systems, and with one exception (oxygen which is taken in by the lungs) is received almost wholy by the alimentary canal. In the lower animals its selection, both as to kind and quantity, is governed almost wholy by wholy by what is known as instinct; which was prehaps origginaly in some sense true to man, but latterly it seems to be governed, almost wholy, by a very singular and eratic somthing best named Caprice; but sometimes foolishly termed reason.

Thus we find that in man it frequently happens that the organs attempt to manufacture without having the right kind of material, and as a natural result he is very prone to disease. The principle of the organs or labratorys are, commencing with the mouth, or the

Morter if you please, in which the food or supplies are ground, is what is called the alimentary canal, which continues with enlargments and narrow parts, turnings twistings, and windings through out the length of the body. This canal including all its turnings is about thirty feet in length. The diffrent parts have received definite names, in the following order.—

Mouth.	Jejunum.	Small Intestine.
Pharynx.	Ileum.	
Oesophagus.	Cæcum.	Large Intestine.
Stomach.	Colon.	
Duodenum.	Rectum.	

This canal is the great central labratory in which our food is prepared for the nutrition of our bodies; but certain parts of it do certain kind of work, while side labratories are stationed along, and add the product of their labor, without which the chemical manipulation would certainly fail.

These organs are the Salivary glands,
" Liver,
and Pancreas.

They aid Digestion by pouring out certain fluids. Besides these the stomac and small intestine secrete chemical substanes also. We will now start with the food, and follow it with its successive changes, considering the fluids poured in upon it, until it arrives at the Cacum.

When the food is introduced into the Mouth, it is first ground and thour-oughly commingled by the action of the teeth; during which operation it is mix-ed very intamatly with the Saliva, a secretion supplied by the Salivary glands.

Saliva is composed principaly of wat-er, which is suspended with a little Phosphate or Carbonate of Lime a pecu-liar proximate principle called Ptyalin.

This substance has a very peculiar action upon starch, converting it into Glucose or grape sugar; but most Phys-iologists contend that this merely acci-dental; that it does not so happe in the animal economy, on account of the interference of the Gastric and other juices. The real chemical action of the Saliva in digestion is still unsettled; although there is no doubt about its action on starch substances when seperated from the system. The function of the Saliva is now thought to be principaly mechanical. It seems very singular that a proximate principle should thus be formed, with such a deffinite and powerful chemical action as is possesed by Saliva, and yet no use made of it in the animal econemy. Yet if there be a definite chemical use for it, Physiologists have as yet failed to discover it.

The mechanical function is clear and

deffinite, it is poured out from the glands which form it into the Mouth during the act of mastication and is intimatly mixed with the food as it is ground, when it is rolled up into a Bolus on the root of the Tongue ready for swallowing. It is coated with Saliva to lubricate its passage down the Oesphagus.

Now we have the Saliva intimatly mixed with the food. The Saliva and Gastric Juice of the Stomac mix readily, consequently the Gastric Juice is quickly dis semmated through the entire mass, instead of attacking the out side first, and slowly proceeding toward the centre.

The food passes to the Stomac through

the Oesophagus in the act of swallowing, and we here meet with the Gastric juice, which is secreted and poured out by the walls of the Stomac itself. This fluid consists of Water, Pepsin, and Lactic Acid, with various traces of salts, but its active chemical properties reside chiefly in the Lactic Acid,

Water	975.00.
Pepsin	15.00.
Lactic Acid	4.78.
Na. Cl.	1.70.
Ca. Cl.	1.20.
NH_3. Cl.	0.65.
Ka. Cl_3.	1.08.
Ca. PO_5.	1 4 8.
Mg O. PO_5.	0.0 6.
Fe O. PO_5.	0.0 5.

peculiar proximate principle, Pepsin. It is always the distructive acid in the reaction.

The Gastric Juice posesses a great solvent power for all substances containing Nitrogen, or Albuminous substances, but does not effect Amylations or starchy substances, sugars, nor oils.

Thus we see that digestion is never perfect in the Stomac, some of the food not being digested at all in it. But those foods containing Albumin, all animal and some vegetable foods, are very perfectly dissolved either in the Stomac, or out of it by the Gastric Juice. If we open the Stomac of a dog, and extract a quantity of the Gastric Juice, and place some meat in it, and maintain the proper temperature, the meat will be digested or disolved, exactly as is done in the dog's Stomac. The same is true of eggs, and many other foods composed cheifly of Albuminous substances. But if fat or oil, starch or sugar, or those grains composed principaly of starch, be substituted for the Nitrogenous substances no action will be had whatever. Excep that the Connective Tissue in which the oil of the fat is held, will be desolved and the oil liberated in the form of oil globules.

Again if we introduce food composed partly of Albuminous and Starchy matters; as we have in the grains and fruits, the Albuminous portions

are disolved out, and the Starch re-
mains unaffected. Thus by these ex-
periments we have the action of the
Gastric Juice clearly defined, both in the
living Stomac and out of it, and found
to be identical. Thus we have it
demonstrated to certainty that this is
a chemical action; and not wholy an
inexplacable vital phenomenon as was
once contended. One singular fact
about the Stomac illustrative of vital
force, and we pass on. The Stomac
itself is composed of an Albuminous
substance, and just such as the Gas-
tric Juice most readily disolves.
Introduce portions of the Stomac of

one dog in that of another and it is disolved or digested with the utmost ease. Then why does not the Gastric Juice disolve the Stomac that secretes and contains it. This is a vital phenomenon, and like most of the vital principles admits no explanation, it stands before us and we see that it is true, and yet it belies all natural laws. Still it is true, and call it a vital phenomenon. Why call it vital? for the reason that just as soon as life is extinct, the Stomac looses its power of resisting the solvent power of the juices which it secretes, and is itself disolved.

In cases of healthy animals shot down after a meal, the Stomac has been found dissolved through in a very short time

and the digestion of the food going on.
We now pass to the Duodenum, where we meet with a new fluid secreted by its walls. This fluid is exceedingly difficult to obtain in a state purity, being always mixed with partialy disolved food and Gastric Juice from the Stomac, and chemists have not yet been able to determine upon its proximate principle. But its chemical action and uses have been fully and accuratly determined, and like the Gastric Juice, it preforms its work just as well and in the same manner out of the body as within it.
We have told you that all starchy foods passed the Stomac unaffected by the Gastric Juice. These substances on passing the

Pyloric Orifice of the Stomac into the small intestine, are at once attacked by the intestinal juice and converted into grape sugar or Glucose. This action is prompt and decisive; one half hour being sufficient for the conversion of a large meal of starchy food into sugar; but this fluid does not disolve Albuminous or Fatty matter. Although any albuminous substances that pass the stomac are generaly digested, it is conseeded that this is done by the action of the Gastric Juice passing on with it.

The fatts and oils are still undisolved; none of the fluids we have yet met with, having any effect on them.

The Pancras, another side labratory, secretes and pours out, a fluid at this point the, Pancreatic Juice, which performs the office of digesting oily substances, which it does by entering itsely into intimate union with the oil, to form a white liquid called Chyle. Chemists do not agree that this is a true chemical compound, but rather consider that chyle is an extreamly intimate immulsion of oil in the Pancreatic Juice, however this may be, the compound is extreamly intimate and also permanant. It is also promptly formed on the two substances being brought togather. Like the Gastric and Intestinal Juices, it preforms the function equaly well, and as promptly out of the body as within it; and like the others, it posesses no power whatever over any other substance than oils.

The composition of Pancreatic Juice is almost identical with the Gastric Juice, except that the Lactic Acid and Pepsin are replaced by the proximate principle called Pancreatine, to which the action upon oils is entirly due.

Thus we see that our food is divided into three groups, and that each group is disolved or digested by a seperate solvent secreted for that especial purpose, and no one of them is capable of acting for the other.

We have yet another fluid poured into the Duodenum through the Biliary

Duct, coming from the gall Blader and Liver, of the action of which unfortunatly we posess no such deffinite knowledge as of those just considered.

This a fluid we hear much of in every day life, it is blamed for more aches and pains, than prehaps all others put togather, one which has been known and talked familiarly of for hundreds of years, prehaps before the others were known, and yet today the one of which we know the least as regards its uses in the economy. It does not disolve or digest any kind of food, and yet no animal can live without its presence in the Alementary Canal, although digestion is in no wise impeded, yet again no animal can live even if it were present in the Canal, unless it be actualy secreted by its own liver.

Unlike the other Juices concerned in digestion, its is secreted from the venous blood, and if it fail to be secreted the blood is poisoned, and the entire skin stained yellow, all of which tends to convince us that it is merely effete matter, which require to be excreated and thrown off from the system.

Yet again a great amount of research has shown that it disappears very shortly from the Alimentary Canal in some maner as yet unknown, and is not thrown off from the system at all. When the Physiologist makes an artificial opening or Fistula to the gall Blader, so that it is discharged from the body without entering the Alimentary Canal, the animal gradualy droops and dies; without any particular disease manifesting itself.

Examinations of the food at different points in the Canal, shows digestion to be as perfect as before, every function, to all appearences, goes on as before throughout its entire length; yet nutrition is imperfect somewhere, and no one has been wise enough to establish the point of failure. Some men it is true have set up theories, which have been quickly knocked down again by others, and so the matter still continues to be the great stumbling block to Physiologists and Chemists.

As to the chemical constitution of the Bile, we have accurate information, no fluid of the body has received closer attention, or more rigid scrutiny by scientific men in all parts of the world.

Bile contains about the same amount of Water, Chlorides and Phosphates as the other fluids considered, but instead of our distinguishing proximate principles, as most others, it contains

four — Glico Cholate of Soda.
Tauro Cholate " " .
Biliverdine.
Cholesterine.

The Glico Cholate of Soda may be percipitated in the shape of very fine needle shaped chrystals, sprangling out in beautiful forms. The Tauro Cholate of Soda may also be percipitated in the form of oil, but has never been chrystalized.

The Biliverdine is the coloring matter of the Bile.

Cholesteine is not formed in the Liver but is merely parted from the Blood, by it and discharged with the Bile. It is now conceeded to be formed in the Brain and nervous tissues, from which it is carried by the Blood to the Liver.

If the Brain be treated with alcohol the Cholestine is disolved out and may be percipitated in the form of very thin, colorless, transparent, rhomboidal plates. We have here the chemical analosis, but unfortunatly we cannot tell much more about it

It is probable that the Bile is in some way decomposed by the Intestinal Juices, and digested food working at the same time some change in them, which is necessary to fit them for perfect assimilation by the system.

This is the last of the Juices we find poured into the canal or in any way acting upon the food, in its preparation for assimilation by the animal economy, We now go back and examine more closely the action of secretion.

Secretion, is the action of a glandular organ, by which a new fluid is produced from the blood, containing one or more proximate principles or chemical compounds not found in the blood itself. It is not a mere filtering through of certain portions, while others are kept back; but it is the formation out of the material found in the blood, of a new chemical substance. As the

Pepsin of the Gastric Juice, Pancreatine of the Pancreatic Juice, and the different salts of the Bile. You will take notice that this is a very different thing from the Osmose, or Endosmosis and Exosmosis we have studied in organic chemistry.

Osmose is the passage of one fluid through a membrane in one direction, while another is debared or even while the same one is prevented from passing back again, or while another fluid may be passing in the oposite direction. But the chemical nature of the fluid is not changed by such passage but only seperated from one with which it had been mixed.

Secretion changes the chemical nature of the fluid entirly, producing an entirly new combination, of an entirly different chemical nature, and the different organs produce fluids of an entirly different character, from one and the same fluid, the Blood, Each organ always producing its own peculiar fluid.

The principle secretions of the animal body, are — Mucus.
Prespiration.
Tears.
Milk.
Saliva.
Gastric Juice.
Pancreatic Juice.

Intestinal Juice.

Bile.

The last five of which have been considered, and the others must be passed for the lack of time.

We ought however to say somthing of the Mucus, and while considering animal heat somthing of Prespiration.

We have, extending throughout the entire length of the Alimentary Canal, and lining it, what is termed the Mucus Membrane, containing numerous small folicals the office of which is to secrete a clear colorless, but extreemly vicid fluid, infact when it is free from admixture with other fluids it is of a semisolid consistence, and the vessel containing it may be turned bottom upward, without its running out. It is much like the other secretions, except that its protimate principle ~~is~~ Mucosine which it contains in the proportion of about 83½ parts in the thousand.

The office of the Mucus seems to be an entirly mechanical one, that of lubricating the membranes and keeping them moist. This membrane and its secretion is not confined to the Alimentary Canal, but prevades all the cavities of the body. The Lungs and Broncial tubes, especialy are lined with it throughout their entire extent.

We have now examined the food in its different conditions, and the fluids it has met with in its passage so far along the Alimentary Canal.

The Albuminous substances have been dissolved by the Gastric Juice of the Stomac, and converted into what is termed Albuminose. The Starchy matters have been converted into sugar or glucose, by the action of the Intestinal Juice, and the fats or oily substances have been converted into an emulsion, called Chyle, by the Pancreatic Juice.

It remains now for me to tell you how these digested matters escape from the Alimentary Canal and enter the

the Blood, where their digestion is rendered complete; for the blood is also in some sense a digestive fluid.

This transfer is accomplished by absorption or Osmose. This is exactly the same action as the Osmose or Endosmose and Exosmose, which we have heretofore studied in organic chemistry, in which the dissolved portions pass through certain membranes, and are divided from the other contents of the Canal without change of charactor.

In this Osmotic action there are three sets of organs concerned, there are the Solitary glands, Peyers glands and the Lacteals, the last of which accomplishes the principle part of the work.

The Solitary glands accur in the upper part of the small intestine, and as their name indicates they are found here and there along the Canal, as small globular bodies, about one thirtyeth of an inch in diameter.

Peyers glands, so named from their discoverer, are very similar to the Solitary, but occur in groups or patches of more or less extent, and are very abundant toward the lower portion of the small intestine, and are the seat of disease in Typhoid fever.

These glands are supplied liberaly with blood vessels, and take up Albuminose by the process of absorption, and deliver it directly to the blood circulating within them.

Far the most interesting of the absorbents are the Lacteals or Villi; these are conical, vascular ~~eminces~~ eminences of the Mucus membrane, of the small intestine; very short and rounded in the upper portion; but much longer and inclined to be club shaped in the lower portion, the larger end hanging out and waving in the contained fluids. The longest of them however are not often more than the thirty fifth of an inch in length; in the human subject.

In the interior of these little organs

are two sets of vessels, one is the Capilary system in which the blood circulates, and the other is what is known to the Physiologist as the lacteal vessels. This last commences in a delicate plexus near the extremity of the ~~of~~ Villi and run in straight or curved lines up to its centre and communicate with a net work of lacteal vessels in the walls of the Canal, which is continuous with the mesenteric plexus.

These Villi or Lacteals hanging out and floating in the fluids of the Canal, are the principle agents in the act of absorption. They may be compared to the roots of the plant.

which are thrown out into the ground, to suck up the material for its sustanence. Like the roots of the plant, they select, by their Osmotic action, that which is suitable, and absorb it through their walls, and thus pass it in for the nutriment of the body.

I said that the Villi or Lacteals have two sets of vessels. Now each set of these minute vessels preform a distinct and seperate work. The Albuminose formed by the Gastric juice, and the Glucose or Sugar from the Starch, pass through the outer coats of the Villi and enter directly into the Blood circulating within them, and is carried to the Liver by the Portal vein. The immulsion of fats or oils in the Pancreatic juice, passes through their walls in seeming the same manner, by Osmotic action; but is taken up by the Lacteal vessels instead of the veins or blood vessels.

We have here one of the finest Osmotic actions known. Of the three fluids all start through the same membrane, by Osmotic action, but two of them invariably land in the blood vessels; while the imulsion of fats alone finds its way into the Lacteals.

I have said that these vessels increase in both size and number, as we pass down the Alementary Canal, until we reach the end of the small intestine, and as the fluids pass along it, those portions fit to enter the system are taken up from it, and it losses in volume, and is robed of much of its fluids, while the solid constituents are passed on into the Colon.

We will now turn from the Alimentary Canal and follow the Chyle or imulsion of fats into the blood. We have seen that this was taken up by the Lacteals, these little vessels gradualy unite togather until they form the Mesenteric plexus, which is a network of Lacteal vessels, and these again discharge the Chyle into the

Thorasic Duct by many mouths.
The Thorasic Duct is situated back close to the vertebral Collumn and passes up, turning in the form of an arch and the Chyle is discharged into the Subclavian vein and mingled with the blood returning to the heart from the circulation. This of course enters the heart and is immediatly sent to the lungs, where it is converted into other substances; prehaps some of the constituents of the blood, by some process as yet unknown, and is entirly lost sight of.

It seems most probable that Chyle one entering the blood undergoes a species of digestion in that fluid, through which it is itself converted into blood. In following the Chyle up the Thoracic Duct, we have come in contact with another set of vessels, and another fluid, which we may as well notice here. I refer to the Lymph and Lymphatic system.

The Lymph is gathered from all parts of the body, by the Lymphatic vessels. which pervade every part of the body. forming extensive networks, and frequently collecting togather in knots forming little glands, and finaly discharging into the blood through the Thorasic Duct.

The Lymph is generaly a limpid,

colorless fluid, but is occasionaly tinged with different colors, or is opake and whitish. It possesses no characteristic proximate principle, and in composition, resembles very closly the Plasma of the blood, and many Physiologists think that it is the fluid portions of the blood, which have escaped through the coats of the capilarys or veins, while others consider it effete matter, which requires to be regenerated in order to be reused or is passed into the blood for excreation.

We have seen that the Albuminose and sugar are taken up by the Villi or Lacteals from the Intestine and passed directly into the blood. These little blood vessels are the commencment of the Portal system, and they gradualy come togather, until they make up the Portal vein, by which they are conducted to the Liver, in which the Albumose is lost sight of.

It is probable that this undergoes a species of digestion in the blood, by which it is converted into blood. How this change is effected we know not, we only know that it quickly disappears and can no longer be detected in the blood, also that this blood does not differ on arriving in the region of the heart from the blood returning from other parts of the system.

The Sugar is not lost sight of so quickly, although this also soon disappears in the same manner. The Liver however manufactures more Sugar than that brought to it by the blood or if the animal is fed on substances that contain neither Sugar nor Starch of which the secreations produce Sugar, the Sugar passing out of the Liver is not very materialy dimminnished, although it may be considerably increased temporarily by a ~~heay~~ heavy meal of Starchy food.

The manufacture of Sugar however

is one of the important functions of the Liver, and it is produced in its tissue and carried out by the blood, although the animal may have fasted for several days, and seems to have an intimate and important connection with the nutrient functions.

This process is carried on in the glandular structure of the Liver, by the act of secreation, which as I told you before is the manner in which new proximate principles are always formed in the animal economy.

It is exceedingly singular that

the Liver will continue to form Sugar in its substance, even after the death of the animal; and more singular still, if the Liver be removed and water be injected through its blood-vessels until every vestage of Sugar is washed out, and then kept at a normal temperature for a few hours, and more water passed through it, it will be found that a consider-able quantity of Sugar has been formed in the interim by its multitudinous glands.

As to the manner of the formation of the Sugar or the substances used we have no explanation except the one fact, that is an act of secreation.

The Sugar found in the Liver is not delivered into any cavity, as is the case with most of the other secreations, but is delivered directly to the blood, and escapes with it by the Hypatic Vein and enters the general circulation, where like the Albumose and Chyle it is quickly lost sight of. and probably converted into blood.

Both Sugar and Chyle are somtimes introduced into the blood more rapidly, than they can be disposed of, as after a very hearty meal entirly of Starchy food or of Oily matters.

In this if it be Starch the whole

volume of the blood may become
Sacharine or in case of oils they may
appear in the blood of all parts of the
body and if it be drawn a allowed
to clot will rise and float in a
thin   on its surface.

Under ordinary circumstances how-
ever they are never found after
the blood has passed the Pul-
monary circulation.

We have now traced the food
through all its changes and exam-
ined its manner of entrance into
the blood. We will now proceed to
examin that fluid, and its circula-
tion and aeration.

Animal heat and the Excretion

Of the Blood.

The Blood as it exists while circulating in its vessels is a thick opake fluid, varying in color in different parts of the body, from a briliant scarlet to a dark purple. It is slightly alkaline in its reaction and is a little heavier than water.

On close examination it is found to be composed of a nearly colorless fluid, the <u>Plasma</u>, in which float multitudes of microscopic bodies, called blood globules. These globules give to the blood its red color and its opacity. There are two kinds, one white and the other red, but the red predominate so largely that the white cannot be distinguished except on microscopic examinations, where we will occasionaly get a few white globules in the field, among some hundreds of the red.

The red globules present a perfectly circular form, with flattened sides, not unlike a watch or an ordinary biscuit, which has failed to rise well, except that they are rather thiner in the centre. Their diameter is about $\frac{1}{3000}$ of an inch, but in this there is some variation, even in the same specimen. They are often seen to arrange themselves togather by their flattened sides, like little rolls of money, sometimes of considerable length, which is probably their arrangment in the coagulated blood, as they would take up less room in this form. Their color by transmited light is a pale amber; but by reflected light is a briliant red.

They have a peculiar consistence, they are not solid bodies, nor are they closed cells containing a fluid, but are homegeneous and of nearly fluid consistency throughout, being soft and jelly like, so that is passing through small apertures in the capillary vessels the accomodate themselves to the circumstances, by changing their shape suit the passage, by lengthening out and reducing their diameter in one direction and thus pass through an aperture of smaller diameter than themselves.

Many foreign substances alter the size and shape, ~~or~~ distroy blood globules. when water is added to them they absorb it and swell up, assume a rounded form and become of a paler red color, and finaly dissolve and disappear altogather. Dilute Acitic acid dissolves them more readily than water and the Caustic Alkalies more rapidly still. If the blood be allowed to dry the globules shivel up and assume a granular appearence. The globules constitute about one half the entire mass of blood, and consist of—

Water	688	parts	in	1,000.
Globulin	282	"	"	" .
Hamatine	16.75	"	"	" .
Fatty matter	2.31	"	"	" .
Undetermined matters	2.60	"	"	" .
Of the diferent salts	8.12	"	"	" .

The most important of these matters is the Globulin, constituting the great mass of the organic matter of the globules. It is soluble in watter but insoluble in the blood plasma on account of the Albumen it contains.

Hamatine is the coloring matter of the blood, and like the globulin is an organic matter or proximate principle of the third class. It is not mechanicaly commingled with the Globulin, but the two substances are intimatly combined into one body.

The Hamatine contains in intimate union a small quantity of Iron as one of its ultimate constituents, directly combined with its other simples Carbon, Hydrogen, Nitrogen and Sulphur. This Iron varies in amount and seems directly concerned in the health of the individual; his powers as the Iron diminishes.

The size of the blood globules vary very much in different animals, measuring $\frac{1}{1200}$ of an inch in the Frog, and $\frac{1}{400}$ of an inch in the great water Lizzard, which is the largest known, and $\frac{1}{120000}$ of an inch in the Musk Sheet, which is said to be the smallest.

The Plasma of the Blood has the following constitution—

Water	902.90	parts in 1000.
Fibrin	7.05	" " ".
Albumin	78.84	" " ".
Fatty matters	1.72	" " ".
Undetermined	3.94	" " ".
Of the various Salts	8.55	" " ".

These ingredients are intimatly mingled in the fluid form by mutual solution, but may be seperated from each other.

Of these Fibrin and Albumin are proximate principles of the third class.

Albumin seems to be the most important ingredient of the blood, if any one could justly be considered more important than another. It is by far the most abundant, and seems largly to control the other ingredients. It is held in solution by the water, which is mostly combined with it and when the Albumen coagulates, the water becomes solid also.

The Salts belonging to the blood are mostly insoluble in water but are held in solution by the Albumen. When the Plasma of the blood is exposed to 160 degrees of heat, after removal of the Fibrin it solidifies almost completely.

The Fibrin may be separated from

the blood, by stiring it with a bundle of twigs, upon which it will soon coagulate in slender threads; when it may be washed free from blood globules and other ingredients and obtained in a pure form. It is a white semisolid of a tenacious, elastic nature and usualy takes the form of threads or flakes, and when once solidified is no longer soluble in water, but dissolves readily in alkalies.

Fibrin generaly solidifies in long dilicate fibers, hence its name. These fibers are exceedingly delicate and tend to arrange themselves paralell to each other. It is to this coagulation of the Fibrin that the cloting of the blood is due.

This process commences almost immediatly after the blood is drawn, or in any way seperated from the circulation.

If the blood be drawn into a bowl, or vessel where the process may be seen, it will soon be observed to become thick, and in a short time the clot is complete, and the blood has the consistence of soft jelly. As soon as the clot is formed it begins to contract, and as the contraction proceeds the Albuminous portions begin to ooze out of it, and after a time the whole surface is covered with a transparent fluid; at first the clot seems to adhere to the sides of the vessel, but as the contraction proceeds it is pulled away, and becomes completely surrounded by the fluid, which has escaped from it, and after ten or twelve hours we find a more or less firm clot, of generaly much less than half its former size, surrounded by a nearly colorless liquid, called Serum.

May circumstances seem to hasten or retard the coagulation of the blood the most important of which, in a practical point of view, is the speed with which it is drawn or flows from a wound. If the blood come from a large orifice, in a flull flowing stream, it coagulates comparitivly slow; but if it comes slowly from a small opening it clots very quickly. It also clots more rapidly when passed over roughened surfaces, than if passed over smothe surfaces; consequently wounds made with a smoothe cutting instrument bleed more freely, than those of a contused or lacerated character; for the reason that & in the first the blood runs away without cloting; while in the latter a clot quickly forms and blocks up the wound; for the same reason blood partialy staid with cloths, sponges or what not is made to clot, by being brought into contact with rough surfaces, and helps to stop the bleeding.

Many diseases have a marked influence upon the coagulation of the blood but we have not time to consider them now.

Blood will coagulate within the body if its motion be stoped, when an artery is tied that blood contained near the ligature, which remains motionless clots just the same as if it had been drawn. When the circulation becomes very weak the Fibrin sometimes clots on the cords and valves of the heart, and becomes the immediate cause of sudden death. So Fibrin maintains its fluidity only so long as it is in circulation.

It seems to be essential to life

that the blood remain permanently alkaline in its reaction. Many experiments have been tried to see if the blood could be rendered acid, but the animal experimented on has always died before acidity has been reached.

These experiments have taken every possible form, but each and all have ended with the one result, death, proving that this cannot be interfered with to any essential degree. The degree of alkalinity may however be varied to a limited extent and no harm come of it.

The entire quantity of blood compared with the weight of the body is estimated to be about as one to eight. That is the body of a healthy man weighing 140 lbs. contains about 17½ lbs. of blood.

The blood is a nutritious fluid, which holds in its composition every element required for the building up and regeneration of all the varied tissues and fluids of the body. Again it is the means by which the worn out and effete material of these tissues is removed and borne away for excretion from the body. Then it not only holds in solution those elements of regeneration, but also commingles with them, the worn out matter to be cast out, and both togather go to make up its bulk.

These varied functions are accomplished by means of its Circulation.

We have shown you how the products of digestion are delivered to it by the Lacteals and Thorasic Duct, and that they, after passing through the Liver and Lungs become themselves blood.

They pass on now as a portion of its general mass, and are again thrown out from the Heart to the geneal system, and spreading throughout its vast Capilary net work, they are appropriated directly to the building up of the tissues, in some manner not yet well understood, while at the same time the blood receives the worn out matter displaced by the new, and bears it on with its seasless current to be excreated and delivered out of the body by the Lungs, Skin, and Kidneys.

Thus it is seen that the blood is the medium of transportation within the body, by which the products of the different organs, are carried to their appropriate place of consumption; and by which the recieve their supplies necessary for the accomplishment of their work.

The Heart and Lungs might be likened to a great Metropolis, where the commerse of a large country centered, where the products of the land were received, and passed in review; purified, and fited for consumption, and again distributed in all those parts needing supplies.

The arteries are the great rivers by which its is connected with every portion of the teritory, and by them the purified material is distributed; while the veins are another great system of rivers, by which the return trip is made and the wastes ~~borne~~ back to be cast away.

In this there is much to attract scientific investigation, much calculated to hold and interest the mind of the Philosopher, and much, very much that might attract the fancy and arrouse varried and fanciful immagination. But we have no time tonight to indulge in dreams.

We will consider, for a little while the apparatus by which this circulation is accomplished.

The construction of the Heart varries very much in different classes of animals, in fact in some of the lower animals it might almost be considered rudimentary, accomplishing very little in the way of propulsion of the blood.

In Man and the Mammalia the Heart is a very perfect and powerful organ, essentialy the same in construction, but differing considerably in the detail among the different species.

It is essentialy a double organ, or there are two Hearts in one, each perfect in itself. One of these receives the blood from the general circulation and throws it into the vessels leading to the Lungs; while the other receives the blood returning from the Lungs and throws it out to the vessels leading throughout the rest of the body.

Each of these Hearts consists of an Aurical and a Ventrical, making in the whole Heart two of each, known as the right and left. The blood returning from the general circulation is received into the right Aurical, and when the right Ventrical dilates it passes through the valvular opening into it, then during the contraction of the ventrical the valves dividing it from the aurical close back shuting it in and it is forced into the Pulmonary Artery. Passing through the pulmonary circulation it returns by the Pulmonary Vein to the left Aurical into which it is received and passes into the left ventrical during the dilation of the Heart; when upon its contraction, the valves of this ventrical close back and the blood is thrown into the Aorta and proceeds to the general circulation.

At the commencement of the great Arteries leading to botho the Lungs and the general circulation, there are als valves placed, which during the dilation of the Heart and prevent any reflux of blood back into the Ventrical.

Thus valves are known by the names of the Aurical, Ventrical, and Arterial valves.

You will see that the circulation is also double or that there are two distinct circulations and the general crculation.

The Pulmonary circulation is that taking place in the Lungs, and its object is the areation of the blood, which we will consider presently.

The general crculation is that which takes place throughout all parts of the body, except the Lungs, comprising its entire extent in every direction, and embracing its every organ. Those which secrete and form new compounds, and those which excrete and free the blood from its load of impurities.

Those which preform the office of digestion, and those which perform the function of assimilating the products of digestion leaving every where that which is needed in the part and baring away that which is not wanted.

We have not time to discribe closly the different parts of the circulation, but will simply say that the Arteries are lost in the tissues, in what is known as the Capillaries or Capillary system.

which permeates every tissue of the body, except the teeth. This system merges into the venous system, which returns the blood to the Heart. In this venous system there are frequent valves, which prevent the blood passing backward, thus causing it always to move toward the Heart. There has often been much speculation as to how the blood is propelled through the veins upward, as from the lower extremities of Man, directly against the force of gravitation.

It has been thought that the motions of the body, and the mussels compressing them here and there, would propell it forward, as the valves prevent it from passing backward, but then it goes forward when the body is motionless. Others again have thought it might have been from suction by the Heart, but this also fails of full explanation.

The force with which the blood is forced through the capillaries by the action of the Heart, has probably much to do with the venous circulation, and it is safe to conclude that it is accomplished by all these forces combined.

Areation of the Blood.

The Areation of the Blood is accomplished in the Lungs during the pulmonary circulation.

The process is essentialy the same in all animated beings, but its manner of accomplishment differs greatly. The essential point in all, is that the Blood shall absorb free Oxygen, and give off Carboncic acid.

In fishes there is but one circulation, the Blood going first to the gills and proceeding directly from them to the general system, instead of returning again and receiving a new impulse from the Heart.

The gills of the water breathing animals, performs the functions of the Lungs in the air breathing animals and usualy consists of filamentous extentions or prolongations of some part of the skin or mucous membranes, arranged in a tuft upon a central shaft, not unlike the plume upon the shaft of a feather, which is sometimes hung upon the outside of the body and waved gently too and fro in the surrounding water. They are most generaly placed however inside just upon either side of the neck, so that the water is taken in at the mouth and passed out through side openings in which the Gills are placed and thus passed through among the filaments as seen in our common fish.

These filaments consist of a delicate network of blood vessels, in which the blood circulates abundantly and the oxygen dissolved in the water is taken up by endosmosis and passes through the membrane and mingles with the blood, while its load of Carbonic Acid passes out through the same membrane by exosmosis and is absorbed by the water. In this way the blood of the fish is freed from its carbonic acid and impregnated with oxygen instead, and converted from a dark color to a bright crimson, and is said to be Areated.

In many of the lower animals the aparatus is very rude, sometimes consisting of a mere sack into which Air is taken, by a kind of swallowing motion and then after a time regurgitated and replaced by more.

These are Air breathing animals, which live much in the water, and often remain for a considerable time under water. In these the Skin takes an important part in the Areation of the Blood, receiving the oxygen from the water and imparting it to the Blood.

In the higher animals and in man the organs of resperation and

Areation of the Blood is far more perfect as well as more complex in their character. They consist of the Bronchical Tubes, which ramify until they are divided into a multitude of minute tubes of delicate structure, until they finaly terminate in exceedingly minute vesicles, termed Pulminary Lobules, lined by an exceedingly delicate membrane, which by a large number of minute folds, containing blood vessels, divides even these minute vesicles, only one twelfth of an inch in diameter, into many compartments, thus increasing largly its surface of membrane.

So great is the extent of this

membrane obtained in the human Lung, by these divisions, that in an ordinary man it is supposed to measure about 1400 square feet or nearly equaling in extent the four walls and ceiling of this room.

The Blood is sent out from the Heart into the Lungs by the Pulmonary Artery, as before explained. This Artery forks and enters each Lung, as is the case with the Bronchial Tubes, and like them continues its bifercations until it is reduced to the finest Capillary net-work, with nothing dividing it from the air in the Lungs but this very delicate, but extensive Mucus membrane already spoken of. Throughout its whole extent the blood comes in contact with it; but nowhere in the Lung does the blood vessels enter the air vessels, but are always divided by this membrane. From this Capillary system the blood is gathered together again by the veins and returned again to the Heart, to be thrown out by it into the general circulation.

The mucus membrane of the Lungs or the membrane dividing the blood in the Capillary system, from the Air in the Bronchial system is an asmotic organ and throughout its entire extent, great as it is, a continuous current of endosmosis and exosmosis is continualy going on. From the Air in the Bronchiae tubes, the Oxygen passes in by endosmosis and mingles with the blood while the Carbonic Acid in the blood passes out by exosmosis, and mingles with the air in the Bronchiae, and by this means the oxygenation of the blood is accomplished, and the blood changed from a dark color to a bright crimson.

The Air is taken into the Lungs by the process of breathing, which I need not now discribe, but all the Air in the Lungs is ~~never~~ never expelled, indeed only a comparatively small portion of it in ordinary respiration, and in the deepest inspiration the air remaining in the Lung, is of course carried back into the smallest tubes before the fresh air taken in, so that if there was not some distributing influence, the air contained in the deeper part of the Lung would merely fluctuate back and fourth and not be changed at all or at any rate very slowly. As a remedy for this dificiency we find the mucus membrane of the Bronchial tubes lined with very minute Cilia or minute hair like enlongations, which keep up a wavy or fan like motion driving the air from within outward. Now as there cannot be a current outward without the air passing in, this results in a double current, one passing inward along the centre of the tube, while the Cilia keep up the other passing outward close to the walls of the tube. In this manner the air in the deeper portions of the Lungs is continualy renewed.

There is also another influence which tends to renew it. This is found in the almost universal law of the diffusion of the gasses which you have studied in inorganic chemistry. When two gasses are placed in the same tube they do not remain seperate, although the lower one may be much the heaviest, but they quickly intermingle, and present the same mixture in every part of the tube. Now as Carbonic Acid is present in excess in the deeper parts of the tubes it will, in accordance with this law, pass outward to mingle with that portion of Air containing but little, and thus be thrown out by expiration.

We see from this that the air suffers change during respiration.

If you take a piece of dry cold glass and blow your breath upon it, it will be immediatly covered with a film of moisture. The air we took in had not a sufficient amount of moisture to percipitate it upon the cold glass.

Then the Air gains moisture. Again if we blow our breath into a receiving jar and lower a candle into it, it will burn very dimly or go out intirely. If we examine it with reagents we will find that it has lost Oxygen and gained Carbonic Acid.

The water given off by the Lungs is exhaled from the mucus membrane, by which it is absorbed from the blood. It is estimated that an ordinary sized man exhales daily a little ~~of~~ over one pound of water, in this way.

In ordinary respiration it is estimated that the Air looses about five per cent of its Oxygen, or about one cubic inch at each inspiration, making in twenty four hours about eighteen cubic feet distroying or unfiting for breathing purposes about 850 cubic feet of Air.

The Oxygen taken into the Lungs is not fully represented by that contained in the Carbonic Acid expired. That is, there is not as much Oxygen in the Carbonic Acid expired as is removed from the air inspired nor yet is there as much in both the Carbonic Acid and Water. Then of course it must be taken in by the Lungs and again thrown out by some other excreting channel for there can be nothing lost.

The proportion of oxygen inspired

and that expired under the form of Carbonic Acid, varies in different species of animals and in the same animal, when fed upon different food. In the Herbivora only about ten per cent of the oxygen consumed is returned with the Carbonic Acid, while in the Carnivora it is near 25 per cent.

A dog when fed entirly on meat will return fully 25 per cent of the oxygen in the Carbonic Acid expired, but if fed entirely on starchy matters he will so return only about eight percent.

The changes occuring in the blood during respiration, as might be expected, are ~~in vers~~ inversely to those taking place in the air. The blood absorbs oxygen and looses Carbonic Acid and watery vapor, and its color is changed from Venous to Arterial or from a dark red to a bright crimson red. It was once supposed that the Carbonic Acid was formed by some process of combustion, but it has been deffinitly determined that such is not the fact, but that it exists in the blood before entering the Lungs in the state of solution or as an Alkaline Carbonate very loosely combined, for it may be removed from the venous blood simply by the Air Pump. The Oxygen taken up by the blood does not combine with it.

chemicaly, but is mere dissolved in it and may be removed in the same way.

The process in the Lungs is then simply one of absorption and exhalation or endosmosis and exosmosis through the moist animal membrane of the Lungs.

It is essential for the activity and nutrition of the tissues that they are constantly combined with oxygen, by the blood and that the resulting Carbonic Acid be carred away by the blood and thus the formation of Carbonic Acid takes place in the tissues themselves and neither in the Lungs nor in the blood.

The oxygen is not held in solution by the Plasma of the blood but by the blood globules themselves.

The Serum of the blood will not absorb oxygen nor carbonic acid but the globules alone will absorb either of them after being seperated from the Fibrin.

If the carbonic acid be not removed from the blood it quickly acts as a poison to the nervous system and distroys life in a very few minutes if allowed to accumulate. This is the reason that it is so impossible for persons to stop breathing even for a short time.

It is essential that the air be comparatively free from carbonic acid for the reason that the Carbonic Acid will not be exhaled from the Lungs, if Carbonic Acid be present in excess in the air we breath~~e~~. That is carbonic Acid will not leave the membrane of the Lung to join carbonic Acid. For this reason continued breathing in a confined space or where many persons are in a close room is deleterious and is especialy calculated to break down the powers of the nervous system and weaken the powers of thought.

The real exchange of oxyen for carbonic Acid takes place in the tissues, not by a direct union of the Oxygen and carbon of the tissues, but in some manner not yet understood.

A piece of flesh from an animal recently killed will continue to absorb Oxygen and exhale Carbonic acid for some time, but if it be placed in an atmosphere of Hydrogen and all Oxygen excluded the carbonic acid will still be exhaled.

Lastly the skin, even of man takes some part in the Areation of the blood although compared with the amphibious animals such as frogs and salimanders it is very slight, indeed but if a man's arm be inclosed for some time in an air tight case, the air within will be found to have lost Oxygen and gained Carbonic acid.

Animal Heat.

One of the most important phenomena presented by animals is that of maintaining constantly a certain standard of temperature independent of external changes of heat and cold. If any inorganic substance, as a vessel of water or a bar of iron be heated up to a 150° heat and placed in an atmosphere at 60°, it will immediatly begin to loose heat by radiation and conduction and in a short time will present the same temperature of the surrounding air, and will maintain that temperature or present the same fluctuations which the air undergoes.

With living animals the case is entirely different. If we place a thermometer under the tongue of the human subject or in the stomac of a dog it will indicate 100° very nearly, no matter what the temperature of the surrounding air may be. This internal temperature is the same winter and summer, whether the subject live under the equator or near the north pole or whether the degree of external temperature be 100° above zero or 40° below zero. No matter what the vicissitudes of the weather may be the internal heat of the living animal never changes more than a very few degrees.

Now the body of an animal placed in cold air looses heat by radiation and conduction in exactly the same manner as the inorganic mass, and the supply of heat to maintain it temperature must be generated within the body by the vital process.

There are two classes of animals in which the power of generating heat differs widely. One is called the warm blooded, and the other the cold blooded.

In the cold blooded animals—reptiles

and fishes — the generation of heat is far ~~more~~ less rapid than in the warm-blooded — Mammalia and birds — and the temperature of their bodies differs but little from the air or water in which they live. There is however no distinction between them except one of degree, for in the cold blooded animals, there is also an internal sourse of heat and they are found to present a temperature of from 2° to 10° above the surrounding air or water and to resist a degree of cold approaching the freezing point with considerable vigor.

In the warm blooded species the

production of internal heat is very active and sufficient to maintain the deffinite temperature against all ordinary oposition. It is greates among the birds their temperature in some species reaching 111°, but generaly about 109° or 110° and in one or two being lower, and in the sea gulls the lowest, 100°.

The thiner and more exposed portions of the body, when the air is very cold, loose their heat fastest and therefore may for a time sink below the normal standard or even be congealed but the internal organs still remain the same.

If the cold be very intense and long continued the vital powers may be overcome and the internal heat be diminished slightly, when the animal will become torpid and insensible. When the temperature of the body is lowered four of five degrees the vital powers fail entirely and death is the result.

Birds who's natural temperature is 110°, die when cooled down to 100°, the natural temperature of the animals.

Each of these species therefore have their own natural temperature at which their blood must be maintained or death is the inevitable result

This heat is generated within the body by changes of a chemical nature and may justly be regarded as a chemical phenomena. In external nature the sources of heat are various.

From the suns rays, the electric current or from the friction of substances against each other.

In other instances it arrises from chemical changes, which is the most abundant and useful source of artificial heat, among these stand first the oxidation of substances rich in carbon as is seen in the burning of wood and coal in our ordinary fires.

These substances evolve a lare amount

of heat during the action of combination and form large volumes of Carbonic Acid.

In all such cases the amount of heat generated may be measured by the ~~an~~ amount of Carbon oxydized or the amount of Carbonic Acid evolved.

It may be made to go on slowly or rapidly according to the abundance or purity of the supply of Oxygen.

If it be supplied slowly the heat will not rise to so great an intensity ~~f~~for it will be radiated to surrounding objects, but it will be continued for a proportionatly longer time so that the amount of heat given out will finaly be as great as if the oxidation went on rapidly raising the heat to great intensity.

Now the Oxygen of the air disappears within the Lungs of the animal and is replaced by Carbonic acid, which seems to be identical with the ordinary oxidation of carbonaceous substances of the inorganic world and it is quite natural to suppose that the two phenomena are identical and Physologists once supposed (and not very long ago either) the Oxygen of the Air united directly with the carbon of the Tissues and fluids of the Lungs producing Carbonic Acid, which was at once returned to the atmosphere the same amount of heat resulting from this process as from an equal volume of carbonic Acid in ordinary combustion of wood or coal. And the Lungs were regarded as a kind of furnace by which the body was warmed.

This theory however has not borne the close scrutiny of the present age. We have already told you that the carbonic acid is not formed in the Lungs, but that it is conveyed to them by the blood also that the Oxygen received is carried away by the blood and not consumed in the Lungs.

This view was accordingly modified in accordance with these facts and it was stated and currently adopted by the scientific world, that animal heat was the oxidation of Carbon in the blood during its circulation.

In accordance with this view, food was divided into two classes; Nitrogenous substances, which were to be converted into the tissues of the body, and Hydro Carbons, as fats and sugars and starch, which were to be taken into the blood solely to be burned and immediatly expelled in the form of Carbonic Acid. There only use being to maintain the animal heat. This view is still supported by the well known fact, that the Greenlander will consume immense quantities of oil, while residents of the torrid zone dare not use it except in small quantities.

The theory has however recently been attact by the German and French Phisologists and Chemists and is well nigh overthrown and the theory of animal heat seems to be in an unsettled condition at the present time.

Dalton says of this theory, "we believe it in fact to be altogather eroneous, and incapable of explaining in a satisfactory manner, the phenomenon of animal heat as presented in the living body", and goes on through a number of pages with arguments to disprove it.

The greater number of learned chemists and physiologists of the present day agree with him in denouncing it.

The theories set up instead of this is that there is no such distinction in regard to the food, but that the Hydro Carbons as well as the Nitrogenous foods are appropriated to the building up of the tissues — that all the chemical changes in all the organs of the body play a part in the production of heat.

That the introduction of Oxygen and the elimination of Carbonic Acid have no direct relation to one another, but that Carbonic Acid is effete matter resulting from a long series of chemical changes, and is no more the result of combustion than the effete matter eliminated by the kidneys.

That Oxygen is as much the food of the body as the solid ~~and~~ liquid ~~the~~ taken into the ~~body~~ stomac and that Oxygen is not any more converted directly into Carbonic Acid, than the food is directly converted into Urates.

Finaly, the numerous combinations and decompositions which follow each other incessently during the nutritive process result in the production of internal or vital heat.

The animal body not only resists the action of cold but also resists elevations of temperature. If the heat of the atmosphere rises above 100° the body still remains at 100° and it cannot be raised but a few degrees above this without causing death.

The prevention of undue heat is ~~produced~~ accomplished by the phenomenon of Prespiration of sweating.

The Prespiration is differently classed by different writers; some classing it as an excretion while others class it as a secretion. It is now pretty well established that it contains a proximate principle not found in the blood and therefore must be classed as a secretion not withstanding the fact that it is thrown directly off from the body.

The Prespiration is secreted by a multitude of small tubular glands situated in the skin and scattered profusely over the whole body, but more thickly in some parts than others.

It consists of water 995 parts in one thousand and its proximate principle ~~1/10~~ ~~of a part~~ is estimated to make up ~~one~~ 1/10 of a part, while the different salts make up the rest. It is distinctly acid in its reaction.

The Prespiration is the safty valve by which undue heat is transfered from the body. It is thrown out upon the skin and evaporates rapidly carrying away the superabundant heat in a latent form, cooling down their surfaces to their normal standard.

So long as the air is dry so that the evaporation can go on rapidly very elevated temperatures may be borne with impunity. Workmen somtimes work in ovens heated to three hundred degrees, and have been known to do so in ovens heated to 400° and 600° for a short time without serious inconvenience.

In these cases the extremities will get hot much as they get cold in cold weather and the men cool their fingers by blowing on them, as they would warm them of a cold day. If the air should be moist so as to prevent the evaporation of the Prespiration they would be baked almost instatly.

Experiments with animals have shown that when confined in heated air they suffer but little inconvenience if the air be dry, ~~so~~ until their supply of Prespiration is exausted, but if the air be saturated with moisture the blood becomes heated and they very soon die.

All Animals consiquently suffer from a warm moist atmosphere, than from a warm dry one.

The Prespiration varies with the temperature, so that no estimate can properly be made of its dily amount.

Excretion.

The last divition division of the nutritive process is that of Excretion.
In order to rightly understand this process we must remember that all the component parts of the living animal are constantly undergoing change.
Incessant transformation and renewal is one of the essential conditions of their existence. Every living animal constantly absorbs certain materials from the external world, which are assimilated by the process of nutrition, and converted into living tissues.

At the same time and in conjunction with assimilation there goes on the equaly incessant process of waste and decomposition, for although the elements of the food are absorbed and organized into different proximate principles of the body, none of them remain permanantly in this condition, but almost immediatly begin to pass by continued alterative processes into new combinations, which are destined to be expelled from the body, while their place is supplied by new assimilations. Experiments have proven that every tissue of the animal frame absorbs oxygen from the air and fixes it in its substance and at the same time exhales carbonic acid, which has been produced by internal changes.

This process by which the ingredients of the animal organic tissues already formed are decomposed and converted into new substances, it is called "Distructive Assimilation".

Accordingly we find that certain substances are constantly making their appearence in the tissues and fluids, which did not originaly exist there and which have not been introduced with the food, but which have been produced by the decompositions of the living tissues. These substances represent the waste of the animal body.

These are the forms under which those materials present themselves, which have once formed a part of the living tissue, but from the changes characteristic of the vital forces are no longer capable of preforming vital functions. They are therefore destined for removal from the body and are then known as, "Excrementitious Substances". These substances have peculiar charactors which distinguish them from other ingredients of the living body and might appropriatly constitute a forth class of proximate principles. They are all of deffinite chemical composition, and are chrystalizable, some of them contain Nitrogen, while some do not, and all of them originate within the living body, and are not found elsewhere except ~~occat~~ occasionaly as the result of decomposition, most of them are soluable in water and all are freely soluable in the animal fluids. They are formed in the animal tissues and absorb from them by the blood to be conveyed by its circulation to certain excretory organs, particularly the kidneys, from which they are finaly discharged from the body. The whole process by which they are formed by the tissues, absorbed by the blood, parted from the blood and finaly removed, is known as <u>Excretion</u>.

The importance of this process to life is shown by the results following its disturbence. If there discharge be in any manner suspended they accumulate in the blood, the tissues or both and in consequence of such accumulation they become poisonous and rapidly produce derangment of the vital functions. Their influence is principly exerted upon the nervous system through which

they produce disturbence of the spec-
ial senses, Iritability, Delerium, and
finaly death.

The readiness with which these
effects are manifested depend upon
the charactor of the substance and
rapidity with which it is produced
in the body.

If the ilimination of the Carbonic
acid be stoped by any means, death
results in a few minutes, but if
the ilimination of the Urea be stop-
ed by inflamation of the kidneys
or the tieing of the Arteries by which
the blood passes to them, it requires
three or four days to produce a

fatal result, but it is sure to follow if the action is not reestablished.

The Excrementitions Substances of the human body with their chemical formulas are as follows, the first is iliminated by the Lungs and the remaind with the Urine.

Carbonic Acid	CO_2.
Urea	$C_2 H_4 N_2 O_2$.
Creatine	$C_8 H_9 N_3 O_4$.
Creatinine	$C_8 H_7 N_2 O_2$.
Urate of Soda	$NaO, C_5 HN_2 O_2 + HO$.
Urate of Pottassa	$KO, C_5 HN_2 O_2$
Urate of Amonia	$NH_4 O, 2C_5 HN_2 O_2 + HO$.

The ilimination of Carbonic

Of the proximate principle of Urine Urea is far the most important, constituting thirty parts in thousand, while all the others togather constitute only thirty two parts water making up the balance. We have not the time to examine each of these seperatly. They are all formed of the worn out ingredients of the tissues and taken up by the blood and consequently all are found in the blood and are carried by it by the way of the renal arteries to the kidneys and by them parted from the blood. From the kidneys they are conveyed by the Ureters to the Blader.

It is estimated that in the adult human subject of average weight, rather more than seven lbs. weight of matter is absorbed and iliminated in each 24 hours as follows—

Absorbed.

Oxygen	1,019	lbs.
Water	7,737	"
Albuminous matter	.369	"
Starch	.660	"
Fat	.220	"
Salts	.040	"
Total	7,070	"

Excreted.

Carbonic Acid	1.585	lbs.
Aqueous Vapor	1.155	" .
Prespiration	1.930	" .
Water and Salts of the Urine	2.130	" .
Feces	.320	" .
Total	7.070	" .

According to this an amount of matter equal to the whole weight of the body passes through the system each twenty days. It is evident also that this is not a simple filtration of foreign matters through the animal frame, but the material absorbed is actualy combined with the tissues and form for a time a portion of the living organism and appear in the excretion only after subsequent disorganizations. None of the solid constituents of the food are discharged under their own form in the Urine, but are replaced by substances of an entirly different nature. The Carbonic Acid thrown off by the breath is not formed by the direct oxidation of Carbon, but originates by a steady decomposition throughout the tissues of the body.

These phenomena therefore show that the substances undergo many changes in their chemical and physical nature, while under the control of the vital forces and that the tissues and fluids of the whole body are incessantly being builded up and broken down, throwing off the old material and replacing it with new, that we live by continual incessant change.

I have now made a too hasty, and too long partly because too hasty a review of the subject of Chemical Physiology, many very many matters of importance have been omited entirly, while others have been only just mentioned, which should have been dwelt upon and more fully explained but I have no apology to make, it is simply the best use I could make of my two hours time in the two weeks notice which I have had.

The End.