ON THE SCIENCE OF SLEEP AND DREAMS.

From ancient times sleep and dreams have been regarded by philosophers and students of nature with the deepest interest. It is, therefore, the more remarkable that until very recently one of the most important questions in connection with the theme—namely, the cause of sleep and the reason of its periodical return, has been but very imperfectly answered. Two years ago Professor Pettenkofer, of Munich, a gentleman widely celebrated for his researches into the cause of cholera, in the course of his experiments upon the exchange of gases in the human system, gave a perfectly satisfactory reply to the inquiry.

It has long been known that the oxygen taken in during the act of breathing plays a very important part, inasmuch as through its union with the substance of our bodies the vital forces are generated. In every process of life, however insignificant, a certain quantity of oxygen is consumed. It is, in a sense, the steam power by which the living machine is driven, and the amount used can be measured by the quantity of carbonic acid generated and set free in the act of expiration. For this purpose Pettenkofer, assisted by Voit, has contrived an apparatus, and has thereby brought to light the unexpected fact that during the day, even with the slightest efforts, we give forth proportionately much more carbonic acid, or, in other words, consume much more oxygen than we receive during the same period.

From this interesting fact there naturally arises the important inquiry, by what means is this daily deficiency supplied? Here, also, Pettenkofer's researches furnish us with a satisfactory answer. Sleep is the prudent minister of finance, who every night, by a wise economy, makes up the losses of the day, for in sleep we not only consume half as much less oxygen as we do in the day, but we take in twice as much as we do when we are awake. During sleep we lay up a store of oxygen which enables us without fear to look forward to the deficiency of the morrow. Is not this arrangement truly worthy of our warmest admiration? Many a state might congratulate itself if its financial administration were conducted on similar principles. Once more we find that nature is the best teacher, giving us a lesson in national economy from the philosophy of sleep.

We have laid down the principle that in every process of life, no matter how trifling it may seem, we consume a certain proportion of oxygen. Every motion, every sensation, even every thought is such a process. If we shake hands with a friend, if we look at him, or affectionately think of him, our heart beating quicker at the thought, we suffer the loss of a definite quantity of oxygen; a certain portion of our body is consumed and changed into carbonic acid. All this sounds horribly material, but it is, nevertheless, perfectly true, and is sustained by the best possible proofs—namely, those arising from the economy of the human system. During sleep its task is to be sparing of oxygen, and like a wise householder, who avoids all useless and luxurious indulgence, and limits himself to such expenditure as is necessary for his subsistence, it faithfully performs it.

But what are these things which we may regard as the luxurious expenditure of our organism? Above all we must include in this category the whole range of the activity of the senses, since such activity is not indispensably necessary for the maintenance of life. In sleep we may strike off with comfort the charges connected with sight. The muscles of the eyes first refuse their service. A peculiar feeling of pressure and heaviness in the upper eyelids informs us that they are preparing for sleep, and the impossibility of fixing the eye steadily upon any object betrays to us the fact that the muscles which cause the convergence of the axis of sight can no longer perform their part. With the closing of the eyelids the excitement of the retina ceases, and the nerves of the eye sink into repose.

The next organs which cease their activity during the process of falling asleep are the ears. Possessing no closing apparatus like the eyes they do not so easily enter into a state of rest. Here, so to speak, sleep has to struggle for its rights. The best example of this we may find in our own experience, if we have been so unfortunate, or shall I say fortunate, as to fall asleep under a tedious lecture or sermon. After we have gradually lost the thread of the discourse, and our eyes are enjoying their well-earned rest, the words still continue to sound in our ears, but we are no longer in a condition to recognize and understand them. Gradually they become more confused, and at length end in a dull and inarticulate murmur which seems to withdraw itself farther and farther from us, until at last it is entirely lost.

In the meantime the sensitiveness of the skin begins to be lessened. In vain our friendly neighbor wearies himself to save us from the annoyance of falling asleep by gently pushing us and treading upon our toes. All his efforts fail. Sensation, if not altogether lost, is so materially lowered that it will respond only to strong provocation. The senses of smell and taste cease their activity, and so at length we are pretty well relieved of all our five senses.

At last the muscles controlled by the will sleep also. When we sleep in a comfortable bed we are hardly conscious of this, and the best opportunity for observing it is when wearied by an uninteresting discourse, we must sleep sitting. Who has not been grieved to find the impertinent muscles of his neck suddenly refusing to carry his head upright? And as long as the struggle between sleeping and waking is continued there is exhibited to the mischievous spectator the highly amusing but treacherous nodding of the head.

Thus the body has, like a frugal housekeeper, discharged its obligations, and unsparingly reduced all expenditure for mere pleasure and luxury. But this is not enough; it materially curtails the charges for the nourishment of its tissues and the renewal of its substance. The action of the heart is diminished to a speed varying from three to ten strokes; the blood comes less often into contact with the general structure, and, therefore, imparts to it less oxygen. Naturally, therefore, the functions of the bodily organs generally are limited, and, above all, suffers that very important organ, the brain, of which we must further speak.

The brain is that organ by which we discharge our mental functions. Whether our views are materialistic or spiritual, we must adhere to the principle that mental activity is inseparably connected with the brain. It is the instrument by which the soul manifests its activity, and, as from an imperfect instrument the most skillful performer can produce only imperfect music, so the capabilities of the mind are dependent upon the state of the brain. As in sleep its nourishment is considerably lowered by the diminished supply of blood, so also, as Durham's experiments upon sleeping animals, whose skulls he partially opened, have shown, the arterial, that is, the oxygen bearing vessels, are more contracted and less abundantly filled than in the waking condition, and, consequently, the capability of the brain is much less. Mental activity is reduced to a minimum, and especially must all complicated processes, above all things the judgment, come to a pause. Still our thoughts and ideas continue to spin themselves out even in sleep, according to the same indestructible law as they do when we are awake, but they lack the regulating and limiting conduct of the judgment and the understanding. This partial activity of the brain is to dream.

The dream is not a dark and inexplicable something of whose origin we are ignorant; it is a product of the same brain function which is active in our waking state. Our thoughts in dreaming depend as much upon the association of ideas as they do when we are awake. In accordance with this law every idea immediately on its rise calls up a series of other ideas connected with it by resemblance of circumstance, similarity of sound in the words which express it, or agreement in the order of time, etc. If, when we are awake, we surrender ourselves to the influence of the law of idea association, and do not voluntarily interfere with it, it comes to pass that when we hear a shot we think of the hunt, and then occurs to us the newspaper report that the king has gone to indulge in the pleasures of the chase, and the similarity in sound probably leads us to think of King, the natural philosopher.

In the waking state the judgment always exercises a restraining influence upon the play of our fancy, and prevents us from joining together the unusual and incongruous; but in sleep our ideas are associated in the lowest manner. When we are awake one idea follows another; but when we are asleep, several ideas simultaneously present themselves, and, uniting together, form themselves into one complex whole; or, from the rapidity with which they follow each other, and the indistinctness of their connection, one idea unobserved takes the place of another, and then we see in the above illustration not the king at the hunt, but King, the philosopher, and thus are originated the most wonderful dream combinations, the source of which we seldom succeed in discovering.

In the waking state we can, as I have already said, call up ideas by an effort of the will. We can think of what we wish. This, however, is not always the case. Very often it happens, as if by accident, that ideas springfrom the treasure of our memory to which we voluntarily give further entertainment, or by which we are unwillingly led to other ideas distasteful to us. So also in dreams, where the voluntary calling up of any given idea is impossible, the mind is led to involuntary activity by means of ideas stored up in the memory. Most frequently the first impetus to a series of dream-pictures is given by some marked and striking impression which has been made upon us during the day, or by thoughts which have occupied our minds shortly before falling asleep. These ideas are often uninterruptedly continued; but not less often we are rapidly led to other ideas, and we are then unable to detect the connection between the two.

When we are awake the impressions of the senses are by far the most prolific source of mental activity. But in sleep, as we have seen, the senses have ceased to exercise their functions, though still, to a certain extent, capable of excitement. Under strong impressions the senses of hearing and of feeling are susceptible even in deep sleep, but the resulting idea is almost always confused, and often an entirely different image is presented; just as in the twilight we sometimes take the trunk of a tree for a man sitting by the wayside. The indistinctness of the impression made upon the senses allows the fancy to fill it up in its own colors, and so it comes to pass that any excitement of the sense of hearing or feeling in sleep gives occasion for dreams, of which only the most general outline originates in external conditions. There are many examples of this on record. Meyer narrates that he once dreamed that he was attacked by robbers, who laid him full length on his back upon the ground, into which they drove a stake, passing it between two of his toes; but on awaking he found that those two members were only separated by a straw!

Another relates that, having a bottle of hot water placed at his feet, he dreamed that he had reached the top of Etna, and was treading on burning lava. In a similar manner, if we are uneasy in bed and throw off the covering, we dream that in the cold of winter we are wandering half clad through the streets; or, if there is a strong wind blowing, we dream of storms and shipwreck; or a knocking at the door produces dreams of an attack by thieves. It is very seldom that words spoken in sleep are distinctly understood, and equally seldom that they call up in the mind of the sleeper the idea they represent. I may mention an instance or two in which dreams could be controlled in this way. Dr. Abercrombie relates that an English officer who accompanied the expedition to Ludwigsburg in 1758 dreamed, to the great delight of his comrades, any kind of dream they chose, according to the words they whispered in his ear. Another example is given by Kluge: A rejected lover, who had secured the favor of the lady's mother, obtained permission to whisper his name in her ear while she slept. Very soon there was a remarkable change in her conduct towards him, and at last she gave him her hand. On being questioned about the change, she replied that she had become attached to him in vivid and oft-repeated dreams. For the truth of this story we cannot vouch; at the same time we do not deny its probability; and any one who pleases may, as a last resort, try its effect upon the heart of his beloved.

The excitement of the internal susceptibilities gives occasion for dreams almost more frequently than the external senses. By internal susceptibilities I mean those sensations which indicate to us the position of our internal organs, and which are usually known as general feelings, and to which belong the condition of being well and unwell. In perfect health we are not anxious of the action of our various organs. We do not feel that we have a stomach or a heart or muscles, etc.; but as soon as there is any functional disturbance of these members, to say nothing of the pain by which it is sometimes accompanied, we are made aware of their existence by a certain undefined sense of uncomfortableness. These sensations come within our consciousness during sleep, but, as might be expected, darkly and indistinctly. Connected with them in a similar manner as with the impressions of the external senses, are certain symbolic dream-pictures, the most common of which is nightmare. This originates in a cramped condition of the respiratory muscles, and a consequent difficulty of breathing. Similar results will follow if the stomach be overloaded, for it then presses upon the diaphragm, and thereby confines the lungs. When we are awake we trace this disordered respiration to its correct cause—namely, a local affection of the organs of the chest, and there it ends; but in sleep we are incapable of this reasoning, and therefore, in harmony with the law of association, there arises from the feeling of oppression the idea of weight and the image of a superincumbent object. We also dream of heavily laden wagons passing over us, or of dark, shadowy apparitions emerging from the ceiling, and gradually settling down upon us.

Not unfrequently we find that, instead of this, we dream of some great trouble or sudden fright, for in the waking state experiences often render respiration difficult. We then dream, for example, that we are attacked by robbers; and when we endeavor to secure our safety by flight, we find, to our consternation, that our feet refuse to serve us, and we remain, as it were, rooted to the ground. We try to call for help, but find that we are unable to produce a single sound, until at last, after long struggling, the muscles of respiration are released from their restraint, and we awake—sometimes with a loud cry.

In a similar manner is experienced the dream of falling from a great hight. It usually happens while we are falling asleep, and depends upon the circumstance that the gradual relaxing of the muscles caused by sleep is, by some momentary excitement, reversed, and the result is a shrinking back of the body similar to that experienced in falling from any lofty position. Somewhat different from this is the dream of flying. According to Scherner it depends upon our consciousness of the action of the lungs, their rising and falling motion giving to us in our dream the notion of flight. There are a great many more conditions of the body which, if they come into our consciousness during sleep, awake in us, in harmony with the law of the association of ideas, a certain kind of dreams. The emotions also produce a definite impression upon their character. "Great joy," some one has written, "originates a different class of dreams than great sorrow; and ardent love gives rise to dreams not produced by hatred, deep repentance, or an accusing conscience."

If we accustom ourselves attentively to notice our dreams, we shall easily perceive the confirmation of the law laid down. But we shall also find that it is exceedingly difficult to reproduce a dream correctly. It is so for two reasons. The imagery of dreams, in by far the greater number of cases, is so indistinct and shadowy, and in its particulars so inadequate, that, by the effort to recall them, we involuntarily bring to our help the imaginative power of our waking moments, and thereby give to them definite color and outline. The other reason is, the innate tendency of the human mind to look at all things in their logical connections. When our dreams consist of a series of pictures, often connected only by the very loose bond of the association of ideas, we bring to them by their reproduction, unintentionally, of course, a logical connection and correspondence with real life which originally they did not possess.

During the period of deepest sleep the function of the brain is so weakened that we retain no recollection of it, and sound sleep has, therefore, come to be called a dreamless sleep. Sometimes we know that we have dreamed, but are wholly unable to recall a single trace of that which has engaged our sleeping thoughts. But shortly before we awake, when the oxygen stored up in the blood corpuscles begins to bring the process of waste and repair in the brain into more energetic operation, our dreams become more lively and connected, and, for this reason, are more easily retained by the memory. The cases are very few in which dreams are so vivid that we are unable to distinguish them from real events. Professor Jessen, a celebrated physician to the insane, gives a striking example, in the following words:

"One winter morning, between the hours of five and six, was awoke, as I believe, by the head keeper, who informed me that the friends of a patient had come to remove him,

and at the same time he inquired whether anything required mention. I replied that he might permit the patient to depart, and immediately lay down again to sleep. I had no sooner done this than it occurred to me that of the intended removal of this patient I had heard nothing, but that it was of the departure of a woman of the same name I had been advised. I was compelled, therefore, to seek further information, and, having hastily dressed myself, I went to the dwelling of the keeper, whom, to my astonishment, I found only half clad. Upon my asking him where the people were who had come to fetch away the patient, he replied, with surprise depicted in his countenance, that he knew nothing of it, for he had only just risen, and had seen no one. This reply did not undeceive me, and I rejoined that it must have been the steward who had visited me, and I would go to him; but as I was descending the steps which led to his house it struck me that the whole affair was a dream—a fact, however, which I had not until that moment suspected."

This example is particularly interesting from the length of time which elapsed after the professor awoke, and during which he had been thoroughly aroused by the act of dressing and going to the keeper, yet the delusion which regarded the dream as a reality continued, and at last, without any apparent cause, suddenly vanished.

Proportionately more frequent are the cases where the awaking is imperfect, but still sufficient to induce a course of action corresponding with the supposed realities of the dream. There are instances on record where people, deceived by the alarming imagery of a dream, have committed acts of violence for which they could not be considered responsible.

An interesting example of insubordination during heavy sleep is related by Büchner, in Henke's *Journal of Medical Jurisprudence:*

"Christian Jünger, a soldier of the guards, two and twenty years of age, and who had been three years in the army, a man of good character, fell asleep about noon upon a bench in the guard house. The corporal endeavored to awake him, in order to sweep out the room. Jünger arose, and, without saying a word, seized the corporal by the breast, then drew his saber and made an attack, which the corporal succeeded in parrying. He repeated the attempt, however, and did not desist until disarmed and arrested by the soldiers present; he then sat down quietly upon the bench. On the preceding day, and on the morning of the deed, he had kept guard at an exceedingly cold and exposed situation; the intervening night he had spent in playing at cards, but had drunk little, and in the morning, from sheer weariness, he fell asleep in the heated guard house. On the examination it appeared that he dreamed he was on guard, when a follow seized him by the hair, and took his rifle, upon which he drew his saber and made an attack upon him. Of that which really passed he knew nothing. He could not understand that he, who had always been obedient to his superiors, should have been guilty of insubordination. The medical evidence showed it to be a case of 'sleep-drunkenness,' and he was acquitted."

In explanation of this case something further may be said. Similar results might be brought about by toil of any kind; but here, by keeping guard, and the consequent excessive exhaustion, the deficiency of oxygen was brought to an abnormal hight, and the small quantity taken in during the short sleep was not sufficient to restore the brain to its full activity. The oxygen still remaining was needed to supply the demands of the comparatively insignificant activity of the impulses of the will, so that the deliberative faculties and the voluntary thoughts could not come into play. We frequently see this confirmed when we wish to awake any one out of sleep. Before he come to perfect consciousness he throws himself about in bed, and stretches his limbs, until at last free thought again asserts its authority over the brain, and consciousness is fully restored.

But we sometimes have phenomena presented to us which are the opposite of this. As Aristotle has already remarked, we are often in a position during sleep to recognize a dream as such. An interesting self-inspection of this kind is related by Beattie. "I once dreamed," he says, "that I was upon the parapet of a very high bridge. For what purpose I had come thither I could not perceive, and when I considered that I had not been inclined to such performances, I began to think that it was only a dream. Wishing to be free from this disturbing and tormenting illusion, I threw myself down, in the expectation that I should be brought back to reason by the fall, which indeed happened." In this example the dream occurred shortly before awaking, and the store of oxygen had manifestly reached such a hight that the organ of thought could act in a limited manner, while at the same time the association of ideas produced in the dream continued.

The same thing has been observed by almost every one in the voluntary effort to prolong a pleasant dream just before waking. In this case, also, the organ of thought is fully capable of exercising its function, but we are in a position to control it a little longer, and to permit the fantastic association of ideas commenced in a dream to continue itself. But when once the activity of free thought has broken in upon this play of the fancy all is over with the dream, and we are irrecoverably awake.

We are restored to the waking state when the supply of oxygen has reached its highest point, and the exchange of substance again comes into full operation. It is possible, however, as every one well knows, to be awoke before this by external influences. Any strong excitement affecting either the nerves of hearing or of feeling or of seeing, by the propagation of that excitement places the brain in a condition which promotes a more plentiful flow of blood, and in consequence of this, an accelerated change of substance, which, on reaching a certain stage, results in perfect wakefulness. Sleep requires, as we have observed above, that the arterial blood-vessels should be but sparingly supplied, and everything which increases the supply of blood to the brain not only prevents falling asleep, but disturbs the sleeper. Therefore, all passion and agitation of the mind, all anxious pondering, or bodily or mental excitement—in a word, everything which drives the blood to the head drives away sleep; on the other hand, whatever takes blood from the brain and contracts its vessels is favorable to sleep. It is in this way that cold bandages applied to the forehead are often successful, for cold causes a contraction of the blood-vessels.

In this connection we must not forget the so-called sleep-producing medicines, especially opium and its alkaloids, among which morphia and narcine take the first rank. From certain experiments it has been concluded, and with great probability of correctness, that opium acts upon the vessels of the brain as an astringent, and thus diminishes its supply of blood. But by such means as these we can secure only a smaller consumption of oxygen in the brain; we cannot at the same time cause more oxygen to be taken in and laid up in the blood corpuscles for future use, for just in those circumstances in which we are compelled to resort to such methods of procuring sleep, the capacity of the blood corpuscles for storing up oxygen, as Pettenkofer's researches in cases of sickness have conclusively shown, is diminished. And so it comes to pass that sleep obtained by means of an opiate is never so refreshing and invigorating. In ordinary circumstances the avoidance of the above-mentioned condition inimical to sleep will suffice to procure it. Here habit plays a very important part. Usually we do not wait for the complete exhaustion of the oxygen of the system, but fall asleep, if we have been accustomed to do so, when it has reached a certain limit. For the same reason we are capable of being awoke at any moment. There is always a reserve fund of oxygen, which makes waking possible. In those cases in which, through excessive watching, the exhaustion of oxygen has reached its extreme limit, the sleep following is so deep that before a certain time has elapsed it is hardly possible to disturb it.

It is not always in our power to avoid those things which hinder sleep, and above all it is only seldom that we can exercise complete control over our mental states. To do this requires either a good deal of stoicism, or an uncommon strength of will and power of self-government. It is said that Napoleon I. could sleep at any time he chose, and did so even during the battle of Leipzic. He had the gift not only of controlling his feelings, but also of suspending thought at pleasure. That the last achievement is by no means an easy one almost everybody has experienced. If some thought or plan occupies the mind we cannot sleep, and we must then endeavor to direct our thoughts to those things which excite but little interest; in other words, we must endeavor to become tedious to ourselves. For this purpose there exists the greatest variety of ingenious methods, and as it does not come within my plan to increase the number of them by this paper, I will here close with the hope that it has awakened in the reader an interest in the phenomena of life as manifested in sleep and dreams.—*Ewald Hecker in the Chemist and Druggist.*

How to Make Bone Fertilizers.

The United States Agricultural Department, having been applied to of late by many of its correspondents to issue some general instructions by which farmers might manufacture their own manures, has prepared the following, accompanied by such remarks as would make the manipulation intelligible:

Bones are almost completely insoluble in water—practically so. When very finely divided, as in fine bone dust, a small amount is dissolved by the water of the soil containing carbonic acid, but the quantity is small, and the time taken to do it is great. For the useful effects of bones, therefore, the farmer must dissolve them, and sulphuric acid is alone the most powerful and economical means for that end. It depends on the different form of bone which the farmer operates on as to how much acid will be required. The sulphuric acid used should be of considerable strength, and the farmer should ask for it of the specific gravity of 1·70 or marking 140° Twaddell.

When the acid reaches the bones, the mass effervesces, boils up, and becomes warm the sulphuric acid taking away two thirds of the lime of the bone from the phosphoric acid, which remains united with the other third, forming a superphosphate, biphosphate, or mono-calcic phosphate, which substance is perfectly soluble in water, and is called soluble phosphate. The sulphuric acid uniting with the lime forms a sulphate of lime (gypsum, or plaster). So that in every heap in which a superphosphate has been made there is always an amount of sulphate of lime (plaster) formed, and the plaster forms the greater portion of the whole mass.

The bones which are used for making superphosphates by manufacturers, or which may be had by farmers, are found in the following conditions: 1. Bone dust or ground bone. 2. Boiled or steamed bones. 3. Bone ash of sugar refineries.

1. BONE DUST.—Before the bones are crushed they are now generally boiled for the sake of the fat, which is sold to the soap boiler. It is of no value as a manurial agent, but is rather deleterious, coating the bone and protecting it from the action of the acid, and it would be advisable for the farmer when possible to boil the bones.

2.—BOILED OR STEAMED BONES.—Bones are steamed for the purpose of removing gelatin or animal matter of the bone for the purpose of converting it into glue. The effect of steaming on bone is therefore to deprive it of some of its organic matter, but it must not be supposed that the whole of the organic matter is removed; a considerable quantity remains, and some ammonia can always be found in such bones when decomposing. A reference to the analysis shows that not more than five or six per cent of organic matter has been extracted from the bone.

3.—BONE ASH.—If bones are burned in contact with the air, the greater part of the carbon is driven off with the other combustible parts of the bone. To avoid this result, which would render the ash worthless for the use of the sugar refiner, the bones are charred in heated iron cylinders, out of contact with the air, by which only a portion of the animal matter is burned off. A large amount of finely-divided charcoal remains, mixed with the bone earth, giving the valuable properties to the bone ash. It has become a great deodorizer and an antiseptic, and capable of condensing gases within its pores, by which means it retains both the ammonia and nitrogen of the soil and the manure. The black color of the bone ash is due to this charcoal.

	Voelcker.		Anderson.
	Bone dust.	Steamed bone.	Bone ash.
Moisture	12·06	8·06	6·10
Organic matter*	31·12	25·45	5·05
Phosphates of lime and magnesia (bone earth)	44·54	60·48	79·20
Carbonate of lime	4·99	3·25	4·05
Magnesia and alkaline salts (chiefly common salt)	1·91	·43	·15
Sand	·35	2·33	5·45
Total	100·00	100·00	100·00
* Containing nitrogen	3·69	1·84	
Equal to ammonia	4·49	2·24	

One hundred pounds of bones, ground, crushed, or dust (not burned), require forty pounds of sulphuric acid (vitriol). This quantity, if acting solely on the bone phosphate, would remove two thirds of its lime; but, as there is always some carbonate of lime present, this is first acted on by the acid, and thus some of the phosphate escapes decomposition, and remains in the mass as insoluble phosphate; hence, in the mass there are always three constituents, the amount of which it is desirable the farmer should know, namely: The soluble phosphate (mono-calcic phosphate), the insoluble phosphate of lime (undissolved bone earth), and the sulphate of lime. These are the three important substances in a superphosphate, for although ammonia may be potentially present if raw bones have been used, yet a superphosphate is not made or used for the sake of the ammonia; and when bone ash or burnt bone is used, no ammonia is required.

If calcined bones, or bone ash of the sugar-house, be the material used, every 100 pounds will require 87½ pounds of vitriol; when these have fully acted on each other the mass would give: Superphosphate of lime, 26 pounds; gypsum, 66 pounds; sulphate of magnesia, 1¼ pounds; soda, 2¾ pounds, and the balance of the 187½ pounds would be water and undissolved bone earth. If the farmer uses steamed bones, a quantity of vitriol intermediate between the two proportions named will be needed, say 66 pounds.

The usual mode of making the fertilizer is to select a good wooden floor of a barn, well covered overhead, or to make a box floor of thick plank, laid tight. On this first throw the bones. If not in dust, it would be well to sift the bones, and place the coarser part on this floor, putting the finer portion aside for mixing in afterwards. By this means the rough bone will come in contact with the strong acid first and be more effectually divided, while the finer parts can then be added to dry up.

No metal (except lead) should be used on the floor, or where the acid can reach. Water equal to one fourth or one sixth the weight of bone is then to be poured on the bone, well stirred in with a spade, and left for two or three days to heat and ferment; it would be well to use the water boiling. Then add the sulphuric acid, mixing well with a wooden spade or board; the mass effervesces, or boils; stir twice a day well for two days, so as to turn the whole mass over; let it stand for two or three days to dry; add the fine bone, and mix well. If not dry, use some absorbing substance, as sawdust, dry peat, or dry earth, in small quantities, and mix well. Do not use for this purpose lime, ashes, or marl, as they would destroy the superphosphate and spoil the whole work.

Made in this way from bone ash, this fertilizer will yield 30 per cent of soluble salts, of which 26 per cent is superphosphate of lime The manufacturer will say that there is 35 to 37 per cent of superphosphate present, but he always over-estimates; indeed, 26 per cent of soluble superphosphates is more than any farmer wants; it is too soluble, and will pass out of his ground too soon, especially in wet weather; 12 to 15 per cent is a better proportion for the farmer, for then he has a proportionally larger amount of insoluble bone phosphate in store for future use in the soil. On this account it is better for the farmer to use raw or steamed bones than bone ash; he has a sufficient, though a smaller, quantity of superphosphate present.

This fertilizer will not suffer from exposure to air, but it must be protected from rain or wet; it ought to be barreled up when not used immediately. This fertilizer, made as directed, will be of a whitish color if made from raw or steamed bone, and gray black if made from bone-black of the refinery; but the color of a superphosphate is of no consequence, and no test of its quality; neither is its smell; it ought to have no smell, or a faint acid odor, if any. One tun of a manure made by the farmer as directed is worth two purchased in the market.

AT the great plow factory of B. F. Avery, Louisville, Ky they turn out five hundred plows per day. Mr. Avery is one of the oldest plow-makers in the country. He worked originally, in 1825, under Jethro Wood's patent.