By the side of these two kinds of researches, each having a bearing upon one element of the question, it is necessary to examine those which have considered the question *in toto*, *i. e.*, to see if an animal subjected to fasting loses more or less of its weight and succumbs more or less quickly to inanition accordingly as it receives caffeine or not. On this subject we find an interesting remark in Hoppe-Seyler *apropos* of the experiment cited above.

"Despite an abundant supply of food, the dog had lost at the end of the experiment about three per cent. of its weight."

Likewise, Edward Smith says that he has observed several remarkable cases where tea, added to the ordinary regimen of prisons, produced a diminution of the weight of the body.

Guimares and Kaposo attacked the question directly. They subjected dogs to fasting, allowing them all the water they wanted to drink; two of them received, besides, a certain quantity of infusion of coffee. These two died quicker than the others.

We have repeated these experiments, modifying them in the following manner to place muscles as far as possible in irreproachable conditions. We never allowed the fasting to go on to the death of the animal. It is known that nutrition is not the same at the commencement of the period of inanition as at the extreme limit, and we took care not to exceed the first period. We employed dogs as the subjects, and studied fasting without and with caffeine. In this way we eliminated the individual differences. The dose varied from one centigramme per kilogramme of the weight of the animal (a small dose) to five centigrammes, a dose which produced an energetic excitation.

In these conditions we did not observe in the weight of the body variations which could be attributed to the caffeine. From this synthetical point of view, then, we find no *action d'épargne* (tissue saving). We deny, then, to caffeine the property which has been attributed to it in different degrees of maintaining the organism in its integrity, despite inanition.

We arrive at this final conclusion:

Caffeine augments the wastes in carbon, and does not restrain the other wastes.

It belongs to us now, with this experimental fact, to explain the tonic action of caffeine on a subject under inanition. We shall abandon the theory of Payen that caffeine is a powerful aliment because it is very rich in nitrogen, and content ourselves with remarking:

1. The doses of caffeine which produce the effects which we have been studying are ridiculously small for an aliment (several grains only *per diem* for a man).
2. The tenure of a substance in nitrogen in nothing prejudices its alimentary value for the animal. Urea is more rich in nitrogen than caffeine; is it an aliment?
3. Caffeine passes out unaltered in the urine. We find ourselves, then, in the presence of a seeming paradox.

Caffeine on the one hand promotes denutrition; on the other, it prevents the injurious effects of fasting.

We shall easily succeed in explaining this phenomenon if we take care to distinguish two cases which seem to have been confounded.

It is one thing to resist inanition a long time when maintaining repose, it is another to perform physical or mental work when fasting for a day or two. Now, it is the latter of the two alternatives that we have in view.

The condition for resisting inanition is to reduce waste to the minimum, if one has to pass a considerable time without food but in inaction; it is in reality, in this case, a waste-restraining action that is wanted. Cold-blooded animals, whose activity is much less than the warm-blooded, resist inanition ten times better than the latter; likewise among the mammals, those whose chemical activity is the greatest succumb the most quickly. We find conditions where the resistance to inanition is enormous, and where the saving of tissues is at its maximum—we refer to hibernation. Now, in this case, what do we see? Absolute immobility, profound sleep suppressing not only the activity of the muscles, but also that of the senses, slowing the respiration and the heart, that is to say, little expenditure, but also no work.

Now with caffeine we obtain just the reverse, *i. e.*, an extensive work; we can, however, obtain it only at the price of the wear and tear of the organism. The law of conservation of energy applies here as everywhere. The animal machine will perform its functions only by consuming combustibles, and it is precisely by energizing combustion that caffeine permits muscular labor during fasting.

We cannot stop to consider metaphysical theories, such as that of medicinal fulminates, according to which, caffeine furnishes to the organism a potential energy accumulated in itself, and which is transformed by the organism into work. This is but playing with words. Caffeine acts on the fasting animal just as it acts on the animal that is fed; the action is identical, and it is the external appearance only of the phenomena which has led physiologists to believe in a special property of caffeine which enables it to replace aliments. It replaces them only from one point of view. We refer to the point of view of the general tonic excitation which the ingestion of alimentary substances produces.

Consider, in fact, the case of a man who performs some kind of work, who is walking for instance: At the end of a certain time there appears in him that state which we call hunger, *i. e.*, with certain special sensations localized in the stomach; he experiences a general enfeeblement; his legs refuse to carry him; it requires an effort of the will to place one foot before the other, an act which he just before accomplished automatically, almost unconsciously; if it is necessary for him to make a greater effort, to leap over a ditch, to climb a tree, he cannot accomplish it at all readily; the heart is slowed, the pulse is small. Suppose now that he eats something. As soon as he has introduced into the stomach a small quantity of food, the discomfort disappears; the vigor and trim return; the pulse regains its amplitude. The sense of well-being is almost instantaneously felt with the ingestion of the first mouthful, especially if the food is warm; the man can now almost immediately resume his walking.

On analyzing this case, let us see what we find: When hunger is felt and has arrested work, it is not because the substances which furnish the energy necessary for this work, fat, glycogen, etc., are exhausted,

and the ingested aliments have not renewed these reserves. In fact, it is the very ingestion of aliments that has revived the failing forces; the effect was produced not only before the food was absorbed, but even before it had commenced to be attacked by the gastric juice. It can only be, then, a nervous action with which we have to do here. We know not what part to attribute to the peripheral excitation consisting in buccal, gustative, and stomachal sensations which make themselves felt on the nerve centers to heighten the tone, nor what part to attribute to the immediate absorption of a very small portion of the aliments immediately soluble and absorbable, such as dextrines, sugars, peptones, etc. It is possible that these two processes co-exist, and both conduce to the effect. It is not the reconstitution of the reserves which enables the man to resume his work, as in the case of the locomotive which takes on water and coal, for the aliments ingested will not be utilized till later; but their ingestion enables the worker to utilize immediately the residue of previous reserves.

The cause, in fact, of that enfeeblement which is an integral part of the sensation of hunger is that the organism, by an instinctive adaptation of itself, restrains its activity and condemns itself to repose in order to diminish the wear and tear of its substance, and to better defend its integrity against inanition.

The researches of physiologists on inanition have taught us, in fact, that, from the very commencement of fasting, the rate of exchanges undergoes a large diminution. The temperature falls several tenths; uric and carbonic acid are excreted in less quantity. As to carbonic acid, for instance, Edward Smith has found the quantity lessened 25 per cent. Ranke, Hanriot, and Richet have given similar figures. The mechanism by which is produced this inhibition of chemical actions consists evidently in a sort of cerebral *engourdissement* or torpor. As it is the nervous system which by its activity regulates that of the organism in general, and as, on the other hand, the nervous system is much more sensitive than any other part of the body to the variations of the internal or external environment, it is this which is first affected; and as soon as the blood begins to be impoverished and the reserves diminished, unless there supervenes some cause of excitation, the organism is brought by the higher nervous influence into that state of atony where effort is impossible, though it may still be in a good condition to long resist inanition. If the latter continues too long, after all the reserves have been consumed little by little, there comes a moment when the nervous system is attacked in its turn by denutrition, and then the final break-down is inevitable; the loss of weight, previously slow, now rapidly increases, and death ends the scene.

But at the beginning of the period of inanition, we see the organism realize of itself that sparing of the tissues which some have attributed to caffeine; it is this very sparing action which is the obstacle to work, and it is by energizing denutrition that caffeine restores activity.

If, in fact, we admit, as has just been set forth, that the ingestion of aliments acts as a stimulant to the nervous system, it is an easy matter to admit that it is possible to substitute one stimulant for another. We know, in fact, that during famines uncivilized populations have recourse to the ingestion of substances which are not alimentary, as the bark of trees and clay. It is plain that this artifice may do good by the mechanical excitations which it produces along the digestive tube; for a stronger reason, it is easy to understand that caffeine, with the excitant properties which we have found it to possess toward the nervous system, may have the power to arouse the latter, restore its activity, and—by its intermediation—that of the muscles; and thenceforth the organism goes on burning its store of reserves and transforming their physical energy into work. Evidently these reserves will eventually be exhausted, and the harder the work, the sooner this will happen. And if alimentation is not re-established, death will come about quickly. This is what was noticed in the experiments of Guimares.

In support of our theory we will consider two necessary orders of facts, where the activity during inanition is equally maintained intact, or even excited, and where the denutrition is evident. The first of these is the action of cocaine. We have seen, in the introduction to this article, that coca is employed in certain countries in the same way as the caffeine plants in others. Now, cocaine produces a hyper-activity of the combustions so great that one may say that it produces fever. As for fever itself, which constitutes the second order of facts of which we desire to speak, its denutritive action is too well known to need demonstration, and everybody knows that febricitates have no disposition to take food, and that despite prolonged fasting their activity is excessive. The comparison of these two cases with the action of caffeine seems to us to be appropriate here.

RESUME.

1. Caffeine in small and repeated doses, about 60 centigrammes a day (which may be prescribed with advantage to soldiers on the march), facilitates muscular work in augmenting the activity, not directly of the muscle itself, but of the motor nervous system, cerebral as well as medullary. The consequence of this double action is to diminish the sensation of effort, and to avert fatigue, which constitutes a nervous and at the same time chemical phenomenon.
2. Caffeine prevents breathlessness and palpitations consecutive to effort, which is of great importance.
3. It thus immediately communicates to a man who gives himself up to violent and prolonged exercise the aid that he requires.
4. In producing this excitation of the cerebro-spinal motor system, on which depends the augmentation of the muscular tonicity, the caffeine augments the waste of the carbon of the body, and particularly of the muscles, but does not restrain the nitrogenous waste. It, therefore, is not, in the strict sense of the word, a means of saving (*moyer d'épargne*).
5. A saving action in general can take place in the higher animals in a complete manner to prevent the injurious effects of fasting, only in a condition impossible to realize, namely, inaction or immobility, more or less absolute, where there is little expenditure without work. With caffeine we observe just the reverse, that is to say, intense work, which we will obtain only

at the expense of the wear and tear of the organism. The animal machine can work only in consuming combustible matters, and it is precisely in promoting this combustion that caffeine permits muscular work even during fasting.

6. Caffeine has not, as is generally believed, the marvelous property of replacing food; it only replaces the general tonic excitation which the ingestion of food produces. It is admitted that it is the direct and instantaneous action of the aliments which stimulate the stomach and nervous system, and that their alimentary value is at first nothing; one might substitute one stimulant for another. Caffeine, far from sparing the reserves, will place a fasting man in a position to undertake his work only by attacking these reserves, the destruction of which it hastens by the excitation of the nervous system, and by its medium that of the muscles; the organism will then soon use up its nutritive supply, and the caffeine will not prevent it. It is, nevertheless, of incontestable but temporary utility for the physical forces.

AFRICAN INSECT WAX.

By J. R. JACKSON, Curator of the Museums, Kew.

THE production of insect wax in some countries forms an important branch of commerce, notably in China, where upon the branches of *Fraxinus chinensis* and an allied plant, *Ligustrum lucidum*, wax is produced in very great abundance, to such an extent, indeed, as often to completely cover the branches with a thick white incrustation. The insect which causes this deposit is the *Coccus Pe la*. The wax, which when fresh is almost as white as snow, and is easily scraped from the branches, is cleared of all impurities by melting and straining, and is employed for making candles, which are used at funerals and for festive occasions, such as wedding ceremonies, etc. Here, then, is a well known commercial commodity among the Chinese, the origin of which is partly vegetable and partly animal. Similar substances occur in other countries, which, if more attention were given to them, might be utilized. Even the dreaded "Australian bug," or, as it is now known, the fluted scale insect (*Icerya Purchasi*), which has become such a pest of late years to many useful plants in New Zealand, California, and South Africa, might perhaps be turned to profitable account, and the creature would thus cease to be the pest which it is now considered. In some parts of the Cape Colony the orange culture has suffered severely from the at-

tacks of these insects, while a similar misfortune has befallen those in New Zealand and California. But the insect is not at all particular in the choice of plants upon which to make its home, besides which it is extremely prolific, and, added to this, it is said that its abundant waxy excretions protect it from the action of insecticides. That this waxy substance is abundant is readily seen by placing one of the insects on a piece of glass and heating it over a lamp, when nearly the whole of it melts away.

These thoughts of the more general utilization of wax or fat producing insects are brought to mind from the fact of a peculiar kind of wax having been shown to me by a member of the staff of *The Chemist and Druggist*, who had recently received it from a friend in South Africa who had found it in Damaraland, where he described it as being used by the natives as a cement for calabashes (water vessels, etc.). To prepare it, he says, it is exposed to the sun to partially melt or soften, when it is used to fill up cracks—apparently like putty—and as it hardens it forms an almost unbreakable cement. This peculiar substance is the product of an insect, and, though apparently common in Africa, is comparatively unknown out of that country.

In the Kew Museums are samples of this wax, both in the natural state and melted and formed into balls; in the former condition it occurs in small irregular pieces, usually about the size of a pea, but sometimes in large agglomerated masses, composed of a number of such pieces. Some, however, are of a lengthened vermicular form, incrusting the spiny twigs of the mimosa upon which it has been formed. Many of these fragments have much the appearance of a caterpillar, and the whole of them are of a dirty white color.

One sample in the museum at Kew is labeled "Gian," or insect wax, from Natal; while another specimen is said to be from a species of mimosa, though the wax is by no means confined to this genus of plants, being found on a number of other trees. It is said to be well known all over South Africa, and to be met with in considerable quantities in Natal. It is the staple used by the Zulu warriors for the making of head rings, and it takes a very fine polish. It is stated that in passing along a road it is quite a usual sight to meet with two or more ring men sitting by the side of the road giving each other a friendly touch or polish before entering a town, village, or kraal, much the same as we should employ a shoeblack. A Zulu so employed is shown in the accompanying engraving, which is from a photograph.

As it is stated that any quantity of the wax is procurable in Natal, it would be quite worth the while of some manufacturer to test its capabilities, when we might also hope to discover the insect which causes it. —*Chem. and Drug.*