the cities of the country. Announcements will be made from day to day, as rapidly as the totals are correctly ascertained, one announcement being made in the morning for the convenience of the evening news-

papers, and another in the afternoon or evening for the morning newspapers. In order to prevent any discrimination, the announcements will be so made that all press associations and Washington correspondents

can obtain the returns at the same time. Papers not having correspondents or press association service may, if they request it, be telegraphed at their own expense the population returns for their cities.

MACHINES AND LIVING CREATURES.

LIFELESS AND LIVING TRANSFORMERS OF ENERGY.

BY DR. WILHELM OSTWALD.

THE similarity between living organisms and machines has often been emphasized and utilized to explain certain structural and functional features of living beings by reference to the simpler conditions observable in machines. In the present article we will reverse the process, that is to say, we shall explain certain peculiarities of machines by reference to facts which are well known and familiar in connection with living creatures.

What, after all, is the reason why we can compare one to the other? We must secure light on this point, since otherwise the comparison will lead us into uncertainty and into a mere play with superficial analogies. The answer is this: Because both machines as well as living creatures are transformers of energy and have the purpose of carrying out the transformation of energy in the way best adapted to the particular conditions of each case.

We know that for every occurrence and for every phenomenon the question arises and can be answered: What energies disappear, and what energies are created? A steam engine consumes the chemical energy of coal and produces from it mechanical energy or work; a horse likewise consumes chemical energy, but in the shape of hay and oats, and also produces mechanical work, and that in a more efficient ratio than the steam engine. The latter, notwithstanding, is the more advantageous transformer because it is satisfied with coal, while the horse must have organic compounds of a very definite nature, since it is unable to consume coal. Man, in turn, is capable of performing mental work, and we have indeed been unable so far to construct a machine for this purpose, hence this kind of labor is qualitatively far above all machine work. But even mental work is based on transformations of energy, for without proper nutrition the mental worker also cannot accomplish anything.

Living creatures therefore are machines, in a certain sense, but they achieve a number of results which we cannot perform with machines proper, in the restricted sense of this term.

Now, there are intelligent people and stupid people, that is to say, some who are capable of performing mental work of superior quantity and quality, and others who cannot do this, and who, therefore, with an approximately equal consumption of raw energy (food) yield a much smaller output of this most precious of all forms of energy. In a like manner, there are good machines and poor ones, the difference being ultimately of the same character. A machine is the better, the more useful energy it yields from the same amount of raw energy.

As a rule, neither a living organism nor a machine is perfect at its first appearance. From the history of evolution of individuals and species, in the sense of Darwin's theory, we are familiar with the idea that a living being gradually adjusts itself to its environment and becomes more and more perfect. We know that the new species is at first very similar to the parent species, but gets transformed more and more, through a gradual atrophy and disappearance of those qualities and organs which are unsuitable for the new conditions, although for a time they continue a useless existence as so-called rudimentary organs. This is one form of adaptation. The other kind of adaptation consists in a gradual segregation of the several functions of the organism among individual organs, each of which is capable of performing its particular work better, that is to say, with a higher ratio of efficiency between energy consumed and energy produced, than the former simpler organism. The simplest form of living organism, a mere minute lump of slime with a nucleus, changes its body according to the need of the moment to act as a foot, a mouth, a hand, or a stomach. Its body, therefore, is a universal apparatus. But anybody who has been the happy possessor of a universal apparatus or combination tool, for instance, a pocket knife with which one can not only cut, but saw, drill, hammer, file, etc., will know that all these things can be done but very imperfectly with a single instrument, and that for serious and fine work it is decidedly preferable to purchase the individual tools separately. Living

creatures have made the same experience, for we can observe quite generally that in the course of their evolution they tend more and more to divide their functions and to perform each function separately by means of a tool or organ ("organ" means tool) developed and adapted to carry out its particular function. The several functions are as many different means of transforming energy. An organ which is most efficient for transforming one kind of energy, will certainly not be adapted to convert any other kind of energy with a maximum of efficiency.

This theory of the origin of species is quite familiar to us as regards its application to animal life, but so far probably nobody has thought of applying it to machines. However, a mere glance at the evolution of any apparatus or process will reveal to us exactly the same peculiarities. We can readily understand, too, that this similarity must exist, for we know that in each case the problem is the same, to wit, finding the most appropriate transformation of energy, and this is solved not at one stroke, but by the slower method of progressive approximations.

For instance, when the thought was first conceived of driving a carriage or a boat by a steam engine, it was carried out by simply placing one of the stationary steam engines then known upon a carriage or boat of usual form, and combining with such engine, the customary propelling means, that is, wheels or oars, with as little change as possible. Thus, even to-day we find upon American rivers steamboats whose engines are still fitted with the old walking-beam, which at the time of the invention was a common feature of the steam engine. Otherwise, the walking-beam has practically disappeared, but in this instance it has been preserved as a rudimentary organ.

As a rule, however, such peculiar forms are not preserved. It is natural and not to be expected otherwise, that the first forms of a new combination adopt the several parts of the previously existing forms without any immediate change. The first question with such a new combination is obviously: Will it work at all; that is, will it produce an operative machine, capable of "life"? In order to answer this question, it often suffices to simply put together the previously existing parts. Only after this fundamental question has been disposed of does the further question arise, whether this form, created in close harmony with existing forms, really represents the most efficient transformation obtainable, and this question must almost invariably be answered negatively. We realize that the same thing can be accomplished in a better way and that, therefore, improvements must be made. For if we do not improve the invention, our competitors will do it and thereby kill the old form. We know that with living beings also competition is the creative reason for development.

Improvement of machinery proceeds along the two paths already indicated for living beings: First, removal of dispensable parts; second, the development of individual organs for the several functions.

The removal of the dispensable parts is simultaneous with a better adaptation to the particular conditions of the new problem. If we consider the first railroad cars, we shall perceive at the first glance that they are simply coaches placed on wheels adapted to travel on rails. Even the superfluous bulged shape of the sides (in turn descended, presumably, from the still older construction of wicker-work coach bodies) has been copied faithfully, although it is much more expensive to manufacture than straight walls, and cushions, which were very essential on account of the hard jolts on bad roads, have little justification in the smooth-rolling rail cars. It is characteristic that these rudimentary forms should disappear first in those cases where passenger accommodations are to be as cheap and as much adapted to the purpose as possible, that is to say, in the third and fourth class (the writer is referring to continental Europe). In the higher classes, where the psychic impression of comfort is sought after and paid for, cushions have been pre-

served to this day. Where, however, the provision of comfort is one of the chief aims, we observe the production, not of a comfortable carriage running on rails, but of an apartment rolling on the track, as in the dining cars and parlor cars of the saloon trains or limited trains.

The other phase, that is, the separation of functions and their performance by individual organs, is likewise recognized readily wherever the development of a machine can be followed through a considerable period of time. The oldest steam engine known to us, Hero's rotary aeolipile, contained all essential parts in a single element, and particularly, it was at the same time a boiler and a motor. But when the real practical development of the steam engine began, the first step consisted in separating these two elements, so that the generation of steam on one hand, and its utilization as a motive agent on the other hand, were assigned to two entirely different organs, each of which could be adapted more perfectly to its particular purpose. In the modern steam engine these two organs or elements in turn have undergone a far-reaching functional subdivision. As regards the boiler, we have a separate development of the furnace, the means for transferring heat, the collection of the steam, and even its drying and superheating. On the other hand, the enormous progress effected by separating the condenser from the working cylinder is well known to everybody who has cast but a glance at the history of the development of the steam engine. It will suffice here to allude to the separate development of such features as the admission of steam, its expansion and distribution, etc.

To examine the history of the development of techniques from the point of view explained above, is not only very attractive, but instructive as well. We not only gain an understanding of what has been done in the past, but acquire a very valuable freedom in our mode of thought concerning present and future forms. For every one who has to deal with a machine or a process of any kind, will now know what questions he has to ask if seeking for improvement. He will have to look at each element and each function and first determine if it has already assumed a form adapted purely to its purpose, or if rudimentary organs have stuck to it, since such organs must be presumed to have existed originally. Secondly, for every operation performed by the machine or by the process he will have to ask: Have the functions been individualized sufficiently, or is not this function or another performed by its organ as a secondary function, as it were, that is to say, imperfectly and not with the highest efficiency?

The restricted space of an introductory article will not permit us to carry out the manifold applications of such considerations even in a single line of development in all the details which give a vivid clothing to the fundamental idea and reveal the inexhaustible variety of its manifestations. But after we have familiarized ourselves with the principles of this new theory, we shall, each of us, readily discover the same leading lines in the development of the industry with which we are best acquainted. If anybody, however, should wish to obtain a conception of the incredible variety of the individual phenomena, though they are all shown to be subject to the same principles of evolution, let him go to the German Museum of Masterpieces of Science and Technics in Munich. There he will find objects placed in the order of their development. And even if there has been no conscious attempt to arrange these objects according to the laws of evolution explained above, still it lies in the very nature of a true law that with good material it will reveal itself spontaneously.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Technische Monatshefte*.

To Cement Ivory.—Solution of isinglass, 2 parts; white gelatine, 4 parts; distilled water, 60 parts. Allow the gelatine to soften and dissolve it by heating, then concentrate it by evaporation to about 10 parts and add powdered mastic 0.2 part; 96 per cent alcohol, 1 part; oxide of zinc, 0.5 part.