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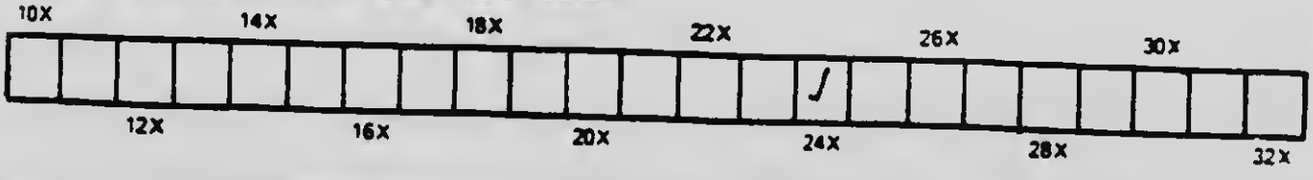

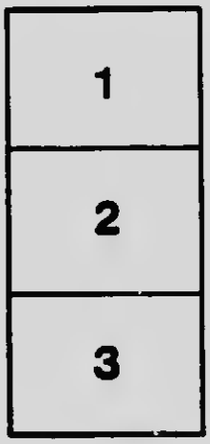

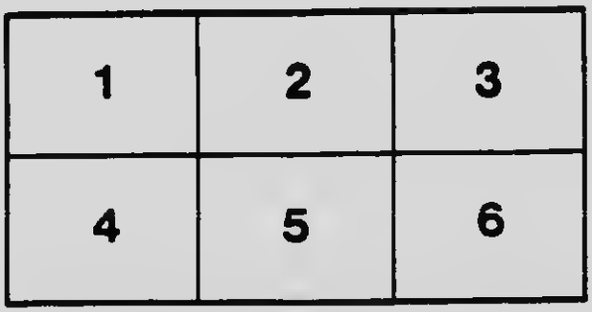

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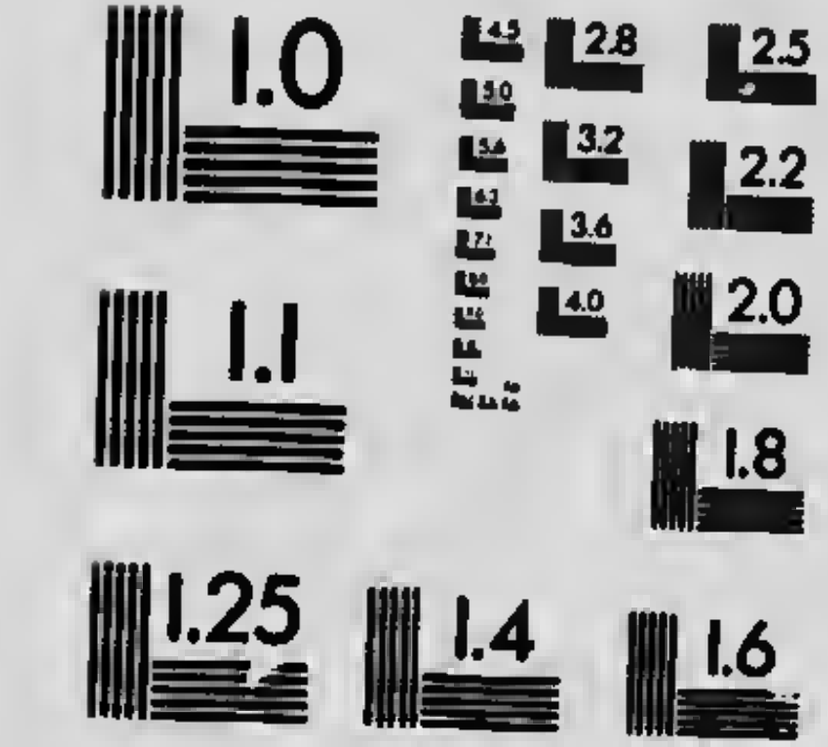

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HOW WE DEFEND OURSELVES FROM OUR FOES

By Professor FRASER HARRIS, D.Sc.

[Reprinted from The Popular Science Monthly, July, 1914.]

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HOW WE DEFEND OURSELVES FROM OUR FOES

By Professor FRASER HARRIS, D.Sc.
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IN a certain sense even now in the midst of his civilized communities, mankind is waging ceaseless warfare against a number of hostile conditions, both animate and inanimate. Serious as this may be now, it must have been much more acute in the earlier times of the race.

Man had to defend himself, as best he could, from the great cosmic exhibitions of energy—the extremes of heat and cold, the tempest, the lightning, the avalanche, the earthquake and the tidal wave. Primitive man, we are assured, must have lived in the midst of alarms of all sorts and in the constant dread of attacks by fierce animals far more powerful than himself. Undoubtedly he sought shelter from wind, rain, snow and frost in those caverns in which his skeleton and the bones of the animals he slew for food and fur are yet to be found.

In many parts of the world he built his wooden hut on piles out from the shore of some lake, so that he had his food supply in the fish under the floor, and was also more secure against the wild animals when his dwelling had to be defended on one side instead of on four.

The latent powers of his nervous system permitted him to develop that speed of running in flight whereby he saved himself from the avalanche, the tidal wave or the beasts of the field. Not alone was speed necessary, but also rapidity of response on the part of his nervous system in order to take warning from the impending danger: that man lived longest who most rapidly reacted to the danger signal, stepped most agilely out of the way of the rolling boulder, skipped most briskly aside from the infuriated lion or bear.

Of course, as we know, he early devised his weapons of offence and fired his flint-tipped arrows at the animals threatening his life or destined to be his store of food for a long time to come. That man throve best who most accurately threw his stone or javelin, so that quickness of response (short "reaction-time") and accuracy of aim—both powers of the nervous system—were early in the history of our race the means of escape from enemies, or the mode of procuring a sufficiency of food.

The first human line of defence is then nervous or mental; our ancestors established themselves on the earth by means of such powers of the nervous system as speed, accuracy and coordination of move-

ments; and these are of supreme importance even yet. He who jumps quickest out of the way of the runaway horse escapes with his life; the old gentleman, whose reaction-time age has lengthened, does not step aside from the carelessly driven motor-car sufficiently perfectly, and so gets run over. Those men who after harpooning the whale got their boat most quickly out of the reach of his tail, were most likely to reach the big ship in safety. He burns his fingers least who most rapidly drops the hot coal.

While, now-a-days, shortness of reaction-time may only occasionally contribute to the actual saving of life, yet it does assuredly contribute towards what is called "success" in life. He who most quickly grasps a situation of danger and acts accordingly, has an advantage over his neighbor with the more sluggishly reacting nervous system.

It is obviously by his development of intelligence—a power of the nervous system—that man has not only conquered nature, animate and inanimate, but has learned to use its forces, even the most hostile, in the interests of his own comfort and prosperity.

Our first line of defence is, then, mental; and the elements of time and precision are all important.

We have, however, to reckon with foes far more subtle and more often met with than the thunder-bolt, the lion, the bear or the electric eel. In some parts of the world, the living things that can poison us are very numerous—venomous snakes, scorpions, countless insects, all ready to pour their poison and acids into our skins. Mankind has learned that alkali will neutralize their acid, and has in these latter days discovered how to manufacture an *antivenin* to counteract the venin or venom of the serpents.

We fight chemical injuries by chemical means. But all these sources of danger or injury are insignificant compared with those which are absolutely and forever beyond the ken of our senses. In common with all other living things, we are surrounded by parasites and preyed upon by them continually. It seems a law of animate nature that any given living thing, vegetable or animal, should have its particular parasite or parasites. For even the vegetables have parasites: the potato has the potato-blight, a fungus; the vine has its phylloxera, another fungus, and so on. The lower plants prey on the higher, the higher on the highest. Fungi and moulds are parasites on both plants and animals. Animals are parasitic on plants: grubs eat the roots and the buds of flowers, the aphides destroy the roses, the Colorado beetle devours the potato. The gooseberry moth strips the leaves off the gooseberry plant; the oak has its galls, everything its blemishes. To such an extent is all this recognized now-a-days that a department of botany, economic vegetable parasitology, has arisen within the last few years. Expert botanists are studying the conditions under which these pests

appear and therefore how we may either guard our flowers and food-vegetables from their ravages, or remove the parasites when once they have settled on their victims. The loss to farmers, fruit-growers and horticulturists each year through parasites is enormous.

Fungi and moulds are parasitic on animals as well as on vegetables; the salmon has the fungoid salmon disease, the grouse has the bacterial grouse disease, the barn-door fowl has its cholera, the swine have swine-fever, the cattle have anthrax and Rinderpest, horses "glanders" and so on.

Then animal parasites infest animals; the frog's lung harbors certain lowly creatures known as Gregarinidæ; dogs, cats, pigs, horses, all have their intestinal parasites, from which obnoxious worms man himself is by no means exempt.

Host and unbidden guest, victim and parasite—this inter-relationship runs through the whole of living nature; it is not the exception, it is the rule. Nature has indeed provided for it; the intestinal worms of the horse have actually developed an *anti*-ferment which prevents their being digested by the digestive ferments of the horse's intestine.

Attack and defence, action and reaction unceasingly, this is nature's method; there is no rest; and there is no splendid isolation; we must be attacked and preyed upon and resist—forever!

A few plants and animals have taken refuge in "protective mimicry"; the dead-nettle imitates its stinging neighbor, and so is avoided by such animals as avoid the latter; some insects imitate dead leaves, twigs, etc., and so are not devoured by insect-eating birds.

But the majority of the foes that man has to battle with are far more subtle than intestinal worms or mosquitoes, or even fungi; for there are myriads of bacteria so light that they float in air even when dust settles; so small that millions can inhabit a drop of water; so numerous that arithmetic is powerless in designating them; so powerful that they have emptied cities, decimated armies and devasted continents. The mortality of the great Boer War had been a trifling thing if the English had had only to reckon with the Mauser bullets; far more deadly the typhoid bacilli than all the guns of all the Dutchmen and their allies.

It is now common knowledge that nine out of ten diseases have an actual, physical recognizable source or cause in some particular parasitic bacillus (rod-like form) or coccus (round form). Undoubtedly some diseases are due to microscopic animal forms, such as ague (malaria), yellow fever, dysentery, the sleeping sickness; but the vast majority are due to vegetable parasites of microscopic size. All those serious diseases known as diphtheria, typhoid fever, cholera, plague, tuberculosis, pneumonia, influenza, rheumatism, common cold, and infantile paralysis, have been shown to be due to the living body being invaded by countless numbers of infinitely minute rod-like or ball-like microbes.

Of course all bacteria are not disease-bringing (pathogenic); and it is well for us that it is so, for the air, earth and water teem with bacteria of some sort. Many are quite harmless and are occupied only with getting rid of dead bodies by putrefactive fermentation.

But our present concern is with our invisible foes, and we must now try to find out how our bodies protect themselves against their presence and their poisonings.

We have three chief methods whereby we defend ourselves from our invisible foes, namely, the physical, the vital or protoplasmic and the chemical.

We possess as an outermost line of defence the intact skin and mucous membranes, the horny layer (keratin) of the skin and the mucus-covered layer on the internal surfaces being impenetrable by micro-organisms.

The living colony—the entire animal—is surrounded by armor, the body is armor-plated, the keratin of the skin is the armor-plating. Once a rift occurs in the armor, a crack, a split, a crevice, an abrasion, a cut or a puncture, it matters not which, then the entrance of our foes is a possibility, nay, a probability. These rifts need not, of course, be perceptible to the naked eye, they may be barely discernible under the microscope, but they are large enough to admit bacilli, and that is all that is needed; diminished resistance within the citadel ensures its conquest. The outer surface of the teeth, the enamel, the hardest tissue known, is indeed not able to be directly attacked by bacteria, but they force an entrance just underneath it and undermine it so that it is easily broken in.

Another physical means of defence is wetness; the wet mucous membranes of nose, throat and lungs retain the dust and bacteria which stick to them. Bacteria wetted are bacteria imprisoned; it is only when dry that they can be wafted about on their disease-bringing errands.

But the mucous membranes of the nose, throat and lungs are covered with cilia.

When we mention cilia, we pass to the second or vital means of defence. Cilia are whip-like prolongations of the cells lining the breathing passages, and they are continually lashing the mucus in which they are immersed with its dust towards the mouth and nostrils. In this way the bacteria caught in the mucus are removed from the body, and thus it is that mucus containing disease-germs should be burned and not allowed to dry, and so set free its burden of bacteria. In prolonged bronchitis, these cilia are known to be absent from the bronchial mucous membrane, thus depriving it of a valuable mode of defending itself from microorganic invasion.

The chief vital agents concerned in fighting our invisible foes are the white cells or leucocytes of the blood. These minute living things

are apparently exceedingly sensitive to the presence or secretions of microorganisms, for they come out of the blood capillaries shortly after the bacteria have invaded the neighboring tissues. Their mode of attack is frontal; they literally fall upon the intruders and, swallowing them bodily, digest them, so rendering them powerless for any further activity.

If the bacteria do not prove very poisonous, the phagocytes are not killed; if however, the poison (toxin) of the bacteria is a virulent one, the leucocytes are killed and their dead bodies constitute "pus," as surgeons call it, or "matter" as other people call it. In suitable preparations for the microscope it is possible to see large numbers of microbes in a semi-dissolved state inside the white cells.

One kind of leucocyte paralyzes or kills the microbes without engulfing them.

Of course leucocytes will do their work well or ill according as they are themselves in good or bad health, vigorous or enfeebled. All exhilarating conditions tend to invigorate the leucocytes, all depressing conditions to enfeeble them.

The leucocytes are, then, the second l of defence—the rank and file of the defending army. When once the outermost physical barriers have been penetrated by the enemy, these living agents take up the defence by active, offensive measures.

The third mode of defence which we possess is the p of our body-cells to manufacture certain chemical substances ving the property of neutralizing the poisons of the bacteria which have invaded us. All the body-cells cooperate more or less vigorously in this the most subtle method of dealing with the soluble toxins manufactured by the bacteria now multiplying in the blood and body-fluids of the unwilling host.

These soluble toxins affect, stimulate, the tissues of the victim, which, being living cells, react, and the expression of their reaction is the outpouring of a chemical something, appropriately called an antitoxin which, uniting with the bacterial toxin, neutralizes it and prevents it exercising its injurious powers. The infected organism thus works out its own chemical salvation by a vital, but no less chemical, response to the poison of the infection. To do this efficiently is to recover, to fail to do so is to remain infected, to be injured chemically, possibly to die.

This production of antitoxin on the part of the infected body is a vital, protective mechanism of a chemical order; it is the chemical reply to a chemical insult. If the attacked body-cells can provide sufficient of this antitoxin to neutralize *all* the toxin made by the bacteria, the individual will not merely get well, but will remain immune from that particular infection for a long time, because, when once

the body-cells begin making antitoxin they make a great deal more than is needed to neutralize all the toxin which the invaders have manufactured.

Hence it is that a person who has successfully come through some infectious disease, smallpox or scarlatina, for instance, can not, for some time thereafter, be reinfected with the poison of that disease; his blood contains an *excess* of the antitoxin of that disease so that any toxin of that kind happening to be produced within him is immediately neutralized. He is immune from or refractory to this infection for a certain time, it may be years. He has fought a good fight microchemically, and his tissues now rest from their labors.

Man has taken advantage of this natural chemical immunity to confer an artificial immunity on himself. When a person gets over an attack of diphtheria, it is because his body-cells, stimulated by the poison of diphtheria (diphtheritin), produced sufficient anti-diphtheritin to neutralize the poison; but it is clear that if he can get anti-diphtheritin ready made, the diphtheritin in his body will be neutralized all the quicker. He makes use of the horse. A horse, which haa recovered from an attack of diphtheria and thus has in his blood plenty anti-diphtheritin (specific antitoxin) has some of his blood drawn off. If a little of this blood, specially treated, be injected into the person suffering from diphtheria, the person will recover, or if it be injected into a person about to go into the infection of the disease, that person will not take the disease. This is conferred immunity; it has been conferred on man by the horse's blood-serum.

Thus we have three kinds of immunity from infection:

I. An original, congenital refractoriness towards the disease which may be called *natural* immunity;

II. *Actively acquired* immunity, the ordinary condition of having come successfully through an infectious illness.

III. Artificially or *passively acquired* immunity, or conferred immunity, one of the latest triumphs of biological science.

All these varieties are chemical means of defence.

Coming under the head of chemical means of defence, we have the existence of an acid in the gastric juice. It is well known that when the acid (hydrochloric) is present in the stomach in the proper quantity, it is uncommon to be infected by microorganisms through the alimentary canal. The author knew of an officer who had come through a severe epidemic of cholera in the West Indies, and who, on being asked if he had been afraid, said: "I had no fear as long as I knew that my digestion was not out of order." We and the other mammals are not the only animals whose alimentary canals are guarded by a free acid; there has been discovered in the Mediterranean a mollusc (*Dolium*

Galea) whose gastric juice contains sulphuric acid. This free grastric acid is distinctly antiseptic.

We have now disposed in a certain fashion of our modes of defence against foes from without; but it is unfortunately as true in a physical as it is in a moral sense that a man's foes are those of his own household. We are liable to chemical assaults from within, whether from poisons secreted by the bacteria inhabiting our internal organs or from poisons arising from the imperfect digestion of our food. Food may have poison in it at the time it is taken, the so-called ptomaines; but poisons may be developed in it in consequence of its not undergoing its digestion in a perfectly healthy fashion. All such digestive poisons are dealt with by the liver. The liver is a very large gland placed in such a position that all the blood coming from the organs of food-absorption must pass through it on the way to the heart.

The liver deals as best it can with the poison reaching it from the intestine; in some cases, retaining it for a time, it eliminates it in an altered form; in other cases it renders it innocuous and permits it to reach the circulation whence it is removed by the kidneys. This power of the liver is known as its *de*-toxicating power. In this way is explained the well-known condition of being poisoned when the liver is "out of order." When the liver is not doing its *de*-toxicating work sufficiently well, not trapping poisons, these pass on into the blood-stream and affect the whole body; the headache and the malaise being the result in consciousness of this general chemical poisoning. Deranged digestion, then, is responsible for the production of the poisons of auto-intoxication which the liver should seize and render harmless.

The chemical defences of some people are so feeble that they are always on the verge of just not protecting them from the poisons of their own intestines, so that such persons are hardly ever free from headache. Other people suffer from periodical outbursts of poisoning associated with one-sided headache (megrim or migraine). Some of the sufferers from this distressing condition have been amongst the most distinguished in science and literature, for Haller, Emil du Bois Reymond, George Eliot and Sir James Simpson were all victims of it.