SCIENCE IN PEACE AND WAR

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SCIENCE IN PEACE AND WAR

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PREFACE

THIS book is a sequel to *Science and Everyday Life*. About a third of the articles in it were written before the present war broke out, most of them during its course. Two opposed views are held as to the function of science in wartime. Some people say war is so horrible and wicked that scientists should have nothing to do with it. Others say that in wartime scientists should desert everything else to increase their country's fighting power.

How, during a period of air raids, anyone in Britain can avoid having something to do with the war beats me. And as for increasing fighting power, you won't do that by neglecting the health either of the armed forces or the civil population. Does anyone suppose that a soldier will fight better because he knows that his children are underfed? My own war research work has been wholly concerned with saving lives of soldiers and sailors. It has been most interesting, and, indeed, at times exciting and dangerous. I cannot yet write about it, for fear of the Official Secrets Act. But I can write and have written in this book about how to save the lives of munition workers.

This book consists entirely of articles published in the *Daily Worker*. We live in a period of such violent change that many of them are already out of date. However, I have not altered them, except for an occasional phrase, though I have added some footnotes. I was not always right, but my readers should be allowed to see where I was wrong, and judge me accordingly.

I want to convince them that in a time like the present we need science more than ever before, that we must think scientifically, not only about weapons and health, but about politics and philosophy, if we are not to share the fate of the French people. So I dedicate my book to all enemies of fascism.

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WHAT SCIENTISTS ARE DOING

ASTRONOMY

IN the series of articles of which this is the first, I propose to take my readers behind the scenes, so to speak, in science, and describe some of the problems which must interest scientists to-day, the problems which, when they are solved, will form the basis of the science of to-morrow.

Research on them is going on in hundreds of laboratories and in the field. The results are published in scientific journals. But they are generally incomplete. And, what is more, the most important work is often the least showy. For it consists in methods. A method for covering a glass mirror really evenly with a thin layer of aluminium may do more for astronomy than the building of a giant telescope. A method for estimating the amount of fat in a drop of human blood may render a scientific investigation of fatness possible.

The plain man complains that scientists are unpractical people concerned with useless problems like counting the hairs on beetles or analysing the light from distant stars, when they should be finding out how to cure colds or make cheap bomb-proof shelters. There is some truth in this criticism, but we scientists have three excuses.

First, science is so badly organised that many of us have no chance to tackle practical problems. Those who work for firms often get no opportunity of investigating fundamental problems; and, owing to industrial secrecy, the workers in university laboratories have too little chance of tackling practical problems. In the Soviet Union things are better. The same laboratories are engaged on problems which they set themselves and problems set them by the directors of industry.

Secondly, a lot of research is done as the result of tradition. A century ago the exploitation of the colonies was a crude process, and the classification of plants and animals very important. It was necessary to know whether a particular tree was teak or a bush tea. To-day economically important plants are grown in plantations. But many people are still paid to classify plants and far fewer to breed them.

Thirdly, the very best research is often quite useless at the time, but immensely important half a century later. Faraday discovered electromagnetic induction in 1831, but electric power was first generated for sale about 1880. In just the same way some people thought Marx was wasting his time in drawing distinctions between labour and labour power, or constant and variable capital, when he might have spent all of it in trying to raise wages. But his theoretical work has borne fruit a thousand-fold in practice. In these articles I am going to deal mainly with research which is now useless, but may become very important.

Let us begin with astronomy, the oldest of the sciences. The main work is done on stars and nebulæ beyond our solar system. Most of this work consists of accurate measurement. For example, all the stars are moving, but most of them are too far away for us to detect their motion directly. So, if a star can be detected moving relative to the others in the same direction—that is to say, appearing in the same part of the sky—it is probably close.

Also the nearer stars seem to move against the background of the further ones each year, owing to the earth's motion round the sun, just as near objects seem to move against the background of far ones if we first shut one eye and then the other. So the modern astronomer can go to bed at night, leaving an assistant to mind the telescope while a photograph is being taken.

But when the plate is developed, he will spend a day comparing it with another one of the same stars taken some years back. And to measure distances between images of stars he uses a microscope. The apparent motions of the brighter stars have all been measured. Some, like Sirius, are bright because they are near, though they do not give out much more light than our own sun. Others, such as Arcturus, are a long way off, but appear bright because they give so much light.

It is quite sure that we know all the stars which give out as much light as our sun, and are within ten light-years of it—that is to say, so near that their light does not take more than ten years to reach us. But we have no idea how many dim ones there may be within the same range. The three dimmest of the near stars were only discovered within the last ten years, and no doubt a lot more will be found.[1] If this is so, it may turn out that very dim stars are far commoner than they seem to be now.

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[1] Several more have been found since I wrote.

In fact, our present astronomical ideas may be as misleading as history, which is mainly concerned with kings and generals and not with plain men and women. And the dim stars, like the ordinary people, are in many ways the more interesting. For the bright stars consist of gas. But some of the dim ones are much denser than anything known elsewhere, and enable us to study matter in a state which we cannot yet copy in our laboratories.

Other astronomers study the chemical make-up of the stars by means of the spectroscope, which reveals the gases in their atmospheres. It might be thought that this was a very impractical activity. But helium, the lightest non-inflammable gas, was discovered in the sun before it was found on earth. Its main use is for filling airships and balloons, and hence Hitler wants it for Zeppelins. If it were found in the British Empire, he could[1] buy all he wanted. But, as it is mainly found in the U.S.A., he cannot.

To-day the study of spectra is not likely to disclose new elements. But it throws a good deal of light on chemistry, in a way which I will explain in a later article. And as some of the stars are much hotter, and the nebulæ at a much lower pressure than anything we find on earth, they are giving us quite valuable information. Above all, the study of stars reveals properties of matter which are well displayed under different conditions of temperature and pressure, but are very much in the background on earth, just as a study of men and women in the Soviet Union shows up human possibilities which are not much developed in Britain, and the study of a primitive tribe shows up still others.

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[1] In June, 1939.

SPECTROSCOPY

Every year[1] my birthday is celebrated with fireworks, for I was born on November 5th. I used to let off fireworks. But now I watch them with a spectroscope. This is a little brass tube. The light enters through a slit, and passes through three prisms. Then a lens brings the rays to a focus again. But the blue rays have been more bent out of their path than the red ones on their way through the prisms. So each colour is represented by the image of a bright line.

If I look at an ordinary hot body, such as the sun or an electric filament, I see a continuous spectrum like a rainbow. If I look at a firework I see one or more bright lines. Each represents a pure light of a particular wavelength sent out by a particular change in a certain kind of atom. I can recognise the brilliant red line of strontium, the green of barium, and so on, as I could recognise the *Leit-motif* of Siegfried, Fafnir or some other character in one of Wagner's operas.

If one reads the works of Eddington and Jeans, one may get the idea that the atom is the realm of uncertainty, and that no exact measurements are possible. And yet the wavelengths of various spectral lines are known with almost ludicrous accuracy. In 1894 Michelson and Benoit measured one wavelength, and when Benoit, Fabry and Perot repeated the work in 1907, the measurements agreed to 1 part in 32 million.

Let us see what this means. The metre was originally defined as one ten-millionth of the distance from the Pole

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[1] Not in 1939!

to the Equator of the earth. To measure the metre with such accuracy would mean determining the position of a Pole within a foot, which is at present impossible.

The metre is now legally defined as the length of a platinum bar, and if this is destroyed—say, in an air raid on Paris—it can be made again correct to 1 part in 10 million with the aid of a spectroscope, provided the wavelength stays steady. According to the theory of the English physicist Milne, the wavelength ought to diminish (or the metal rod expand) by about 1 part in 2,000 million per year. Unfortunately, he is not likely to live long enough to see this theory proved or disproved. But this will be possible in a century or so.

Usually spectroscopists only aim at an accuracy of about 1 part in 1 million or less. But hundreds of papers are published every year giving new measurements of wavelengths. A gas is highly purified, an electric current passed through it, as in a neon lighting tube, and the different colours separated, not by means of a prism, but a grating. This is a plate of quartz or other hard stuff ruled with about 20,000 lines to the inch, so that, like a pearl or a beetle, it reflects different colours at different angles.

These spectra are very complicated. A single kind of atom may produce thousands of different sorts of light. We want to know more about atoms, and we naturally concentrate on those of their properties which can be measured with great accuracy. Some others cannot, and this fact has been erected into the "uncertainty principle," which is supposed to imply that there is nothing there to measure, and that matter really only consists of ideas.

The true explanation was first given by Lenin, when he said that the properties even of an electron are inexhaustible. When he wrote, physicists regarded the electron as something like a very small billiard ball, endowed with the property of pushing away other similar billiard balls with a force that fell off with the square of the distance between them. This was a very useful idea for some time. An atom of oxygen behaved fairly like a system of eight of these little balls spinning round a rather larger ball.

However, if you persist in trying to measure things which could be measured if electrons were little balls, you don't get a clear answer. This means that electrons are not little balls. It does not mean that they are not real. They are real enough to have properties that are constant to 1 part in 30 million, which is more than can be said for most things.

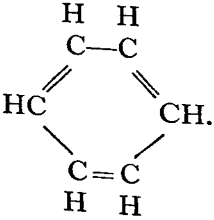
Other spectroscopists are concerned with molecules, that is to say groups of atoms forming definite chemical substances. Their colour depends on what sorts of light they absorb. The energy of the absorbed light may be turned into heat. It may be emitted at once as light of another sort, as when diluted red ink gives out a green light. It may be emitted as light after some time, as with luminous paint. Or it may cause a chemical change—that is to say, a rearrangement of the molecule.

"What has that got to do with ordinary life?" you may ask. It happens to be the basis of the photographic industry, which includes the cinema industry, and employs millions of workers. It is only by careful study of what happens when light hits a molecule that we are at last beginning to understand what happens when light strikes a film and produces the "latent image," which is then developed.

In this case theory lagged behind practice for about a century, just as in the case of metallurgy it lagged for thousands of years. It may take another generation before the new theories are fully applied. But their application should mean the production of hundreds of different kinds of photographic materials each adapted for a special purpose, and surpassing the best plates and films made to-day as completely as our modern steels surpass those with which the knights of the Middle Ages went into battle.

ORGANIC CHEMISTRY

FORTY years ago chemists were mainly occupied with making new compounds and finding out the structure of compounds which were previously known. The greater part of such work was done in the field of organic chemistry—that is to say, the chemistry of complex carbon compounds, some of which are made unconsciously by living plants and animals, whilst others were first made consciously in a laboratory.

An organic chemist aims at producing a structural formula—that is to say, not merely stating how many atoms of various kinds there are in a molecule, but how they are arranged. For example, benzene is not merely C_6H_6 but  That is to say, there are six carbon and six hydrogen atoms arranged in a symmetrical ring.

The chemists said this must be so because, for example, if we let chlorine act on benzene, it replaces the hydrogen gradually. And there is only one compound, C_6H_5Cl, in which one chlorine atom replaces a hydrogen. But there are three different kinds of $C_6H_4Cl_2$ and three of $C_6H_3Cl_3$. You can work out easily enough that this must be so if the atoms are arranged in a ring.

Kekulé, who first thought of this structure, said it came into his head when he was sitting on a London bus and watching the patterns formed by people in the street. And he probably thought that atoms were about as real as people. Other chemists said such formulæ were a useful shorthand and no more; and no one could ever know how atoms are really arranged.

But in 1912, Laue in Munich noted some peculiar results when X-rays pass through certain substances, and Bragg (now President of the Royal Society) followed up this clue in Australia, and showed that X-rays have wavelengths about as big as the distances between neighbouring atoms. So if X-rays going in a particular direction through a crystal meet atoms arranged in a regular series they are reflected if the distance between atoms is half the wavelength of the rays. The principle is just the same as that which makes a pearl or a beetle's wing case reflect light of different colours in different directions.

The theory is quite complicated, and it was first applied to simple compounds like common salt, and only later to large molecules. When X-ray photography was applied to organic compounds, they showed at once that the formulæ were not shorthand, but a true picture, and that the chemists had been right.

But not always. Sometimes the X-ray photographers have been able to put the chemists right. I had long thought there was something fishy about the formulæ which chemists had given to a number of greasy substances, such as cholesterol, which is found in most living cells, and vitamin D. Finally I got my colleague Bernal to take an X-ray photograph of a crystal of one of them. He said at once that the official formula couldn't be right, and a few months later two chemists produced the correct one.

Since then he has largely deserted the study of mineral crystals for those of organic compounds. He is one of hundreds of men and women who are engaged in this work. Some are studying the arrangements of atoms in metals, others in fibres such as cotton, wool and silk, and their work has already had important technical results, both in the metallurgical and textile industries.

Apart from this, chemists have mostly become less interested in structure, and more so in change. They are finding out the laws which govern the rate of a chemical process, whether it is a quick one, like the explosion of a mixture of air and petrol vapour, or a slow one, like the rusting of iron.

The most fundamental question is this: Why is a particular molecule or set of molecules unstable? Thus hydrogen peroxide gives off oxygen very easily, and water does so only if you pass an electric current through it. A hydrogen molecule and an oxygen molecule do not interact at ordinary temperatures, but do if they are very hot—that is to say, moving very fast. And so on.

The basic principle is that a molecule becomes unstable if it has too much energy for its structure. This is why heat, which means increased molecular motion, speeds up almost all chemical changes. The general rule is that all molecules with more than a certain critical energy, or all pairs colliding with more than a certain energy, will undergo change.

The extra energy needed for change may come from heat, from light, or from another active molecule. And the results of spectroscopy, which show that molecules take up energy and give it up in definite steps, enable us to calculate the speed of chemical reactions.

The same principle runs right through science. When a shaft reaches a certain critical speed, it does not spin evenly round its axis, but begins to whirl—that is to say, to bend out of the straight. Our own society is unstable for just the same reason, that the productive forces are too powerful for the productive relations. So we get overproduction, which means, not the production of more commodities than people can use, but the production of more than they can use under capitalism.

In the same way, when a molecule of trinitrotoluene (T.N.T.) is heated up, it has more energy than the atoms can carry so long as they are in that particular arrangement. But they can carry that amount of energy, and a great deal more, if they are arranged in stabler patterns, such as nitrogen and carbon dioxide. So there is a sudden and drastic rearrangement, and the trinitrotoluene explodes.

The chemistry of last century was largely a static chemistry concerned with structure. That of to-day is becoming more and more dialectical, as the interest of chemists passes from the study of pattern to the study of change.

BIOCHEMISTRY

THE workers in chemical laboratories are now more busy testing the properties and rates of change of known substances than in making new ones. But just the opposite is happening in biochemical and physiological laboratories.

When I was a biochemist I used to work at the physiology of breathing. I found out that some chemicals increased the speed at which a man or a rat uses oxygen, and others slow the process down. I also found that a substance which Warburg, in Berlin, had shown to be responsible for much of the oxygen uptake or "breathing" of yeast was doing the same thing in cress, bacteria, moths and rats.

But I didn't try to purify it, because, although I am rather good at measuring small amounts of gas, I am no good at separating chemical substances out of a mess. This substance was an example of the class of substances called enzymes, which exist in all living cells, and carry out chemical reactions with great speed.

For instance, yeast makes alcohol out of sugar. This is a process carried out in many steps, and each enzyme carries out a small step only, like workers on a conveyor belt. But each enzyme can cause changes in many times its weight of sugar or intermediate per second. So a cell only needs a very small amount of each enzyme, and they are very hard to purify. In fact, when I wrote a book about them eight years ago, only one had been purified, by Sumner of Ithaca, U.S.A., and I was not quite sure that he had really done so.

The purification is a highly skilled job. A biochemist starts with mashed-up yeast, sweetbreads or some other living substance which contains the enzyme, and then works out a test for the amount present in a sample, based on the amount of change it can cause in a given time—say, ten minutes—under fixed conditions.

Then he tries to concentrate it. He must not heat up his mash, for quite moderate heat destroys enzymes. He must keep it free from bacteria which may destroy the enzyme; but he must take care that his antiseptics don't destroy it, too. Then he adds something, perhaps common salt or acetone, to his mash, and some of it falls down to the bottom. If he has luck, all the activity—that is to say, all the enzyme—falls to the bottom or perhaps stays in solution, and he has rid the enzyme of some impurities.

In such ways as this, enzymes have been gradually concentrated, and about fifteen have been obtained as pure crystals. The champion purifier is Northrop of New York. Every one of these enzymes turns out to be what is now called a "protein," but what Engels called an "albuminous substance."

Now Engels said that life was the mode of existence of albuminous substances. Can we say that enzymes are alive? Probably not, although if we leave the right set of enzymes with a foodstuff such as sugar, it will take up oxygen—that is to say, breathe. We can't yet use the energy of the process to do work, as occurs in a contracting muscle.

It took the best part of a million years between the invention of fire and the harnessing of fire to work a steam engine. It will not take so long as that to set enzymes to work. When we can make enzymes, and also organise them into a system which will do work and repair moderate degrees of damage done to it, we shall have what may be reasonably called an artificial living being. This ought not to take more than a century or two. We can now supplement what Engels wrote, and say that life is the mode of existence of albuminous substances arranged in a particular manner.

Other biochemists are purifying vitamins, of which I wrote last year, and hormones, of which I hope to write when the football season makes the Wolves news once more.[1] None of the vitamins are proteins. The proteins are giant molecules weighing from 15,000 to several million times the chemical unit, which is roughly the weight of a hydrogen atom. But the vitamins are moderate-sized molecules weighing less than 1,000 times a hydrogen atom.

However, some of the vitamins, when attached to the right sort of protein, act as enzymes, just as the right sort of tool makes a lathe suitable for a particular job. For example, vitamin A attached to a particular protein makes the light-sensitive stuff in the eye, and one of the components of vitamin B attached to another makes an enzyme concerned in breathing.

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[1] See p. 54.

This research on separating enzymes will probably go on for another generation or so in biochemical laboratories. The next stages will be to find out exactly how they work, and then to make others which do the same work better. Just as we use artificial coal-tar dyes instead of natural dyes like woad and madder, our descendants will probably use artificial enzymes instead of natural yeast to brew their beer and wine (if they still drink them), prepare their leather for tanning, turn their milk into cheese, and so on.

Of course, a little work has already been done on how enzymes work (I did some myself), but until we understand their composition exactly, and can take them to pieces and put them together again, we shall not get very far. The whole story illustrates the way in which scientific research switches over from the study of function to that of structure, and back again. And it also shows that there are no real boundaries between different sciences such as chemistry and biology. Nature is one, and the scientific method is the same, whether we apply it to rocks or roses, bacteria or bankers.

MINERAL CHEMISTRY

THE eighteenth century was the great age of collectors. Dead animals and plants were stored in museums, and Linnæus classified them into species, genera, families and so on. Others collected stones, especially crystalline ones, and classified them into a "mineral kingdom." Some kinds of rock, such as quartz, consist almost entirely of one mineral "species." Others, like granite, contain a fair number, as one can easily see by looking at a polished piece of granite.

Each kind of mineral has its special crystalline form, specific gravity and so on; and they were classified, and given names, sometimes very picturesque ones like "luxullianite," which was first found at Luxullian in Cornwall. Later on their chemical composition was worked out, and it was found, for example, that it was useless to look for quartz in Kent, at least within a mile of the surface, or flint in Cornwall.

Some people still thought that God, when he created the world, had put the minerals where they are now found. But this was certainly not always true, because some kinds of minerals were actually observed to crystallise out from the lava of volcanoes when it cooled down. And now every geologist agrees that rocks were not created as they are, but have a history.

Another awkward discovery was that hardly any natural minerals are as pure as the purest substances we can make in the laboratory or in industry. And sometimes there was an entire range of mixtures bridging the gap between two mineral species, as if there was a continuous series of animals between a cow and a sheep, which, of course, is not the case to-day; although such series did exist in the past, since the sheep and cow were descended from a common ancestor.

Mineralogy has been revolutionised in the twentieth century. One revolutionary agency was Bragg's technique of crystal analysis by X-rays, of which I wrote earlier. This showed not merely what atoms occurred in a mineral, and in what proportions, but how they were arranged. Instead of having to measure the crystalline form of a mineral or look it up in a textbook, one can now calculate it. And the validity and "this-sidedness" of the theory have been shown by the prediction of the crystalline forms of hitherto unknown substances.

Goldschmidt, of Göttingen, made a further step. It had long been known that certain crystals often contained "impurities"—that is to say, quite small amounts of elements which were not responsible for their general form—though they were often responsible for their colour. In fact, the colours of precious stones are generally due to "impurities."

Goldschmidt showed that even these impurities were subject to laws. Rare elements such as gold and platinum are found where they are largely because they fit into the interstices of crystals in a way which is quite intelligible when the structure of the crystals is fully understood. Goldschmidt was expelled from Göttingen and had to leave most of his minerals, instruments and books behind.

But he found refuge in Oslo (which, by the way, is much more Nordic than Göttingen) and has stated that his work was greatly improved in the long run because he had to begin it again at the beginning. Unfortunately most other people in similar positions have not been so lucky.[1]

But the most remarkable developments of all have been in experimental petrology. Many people know how Benjamin Franklin sent up a kite into a thunder cloud, got

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[1] I wrote too soon. I do not know if Goldschmidt is alive or dead to-day. Presumably he is no longer working in Oslo.

electric sparks from the wet string, and proved that a lightning flash was only a giant electric spark. He was a brave man, but Jaggar, another American, who first measured the temperature of a volcano, is probably braver, for volcanoes kill many more people than thunder storms.

Jaggar has thrust thermometers in metal tubes into the glowing lava of the volcanoes of Hawaii, and thus discovered the actual temperature of the molten mass from which various minerals crystallise out. And other workers have studied the behaviour of matter under high pressures and temperatures.

The combination is by no means easy to achieve. One can get very high temperatures in an electric arc at ordinary pressures. Or one can get high pressures at an ordinary temperature in a steel press. But how is one to keep up a high pressure at a temperature which softens steel? A miniature electric furnace is used within a steel cylinder under high pressure. But the cylinder must be full of a liquid, and this drains the heat away.

So a great many special problems of design had to be faced. They have been at least partly overcome, though the "experimental volcano," where both pressure and temperature are high, may be no bigger than my thumb. Still a great deal has been found out. We know how the melting points of many minerals vary with the pressure. Generally, the higher the pressure the harder they are to melt.

We also know something about solubilities. Generally molten rocks will hold a good deal of water in solution, which they give up when they cool down. This accounts for the great clouds of steam which have caused some of the worst volcanic explosions. And at last we are getting a rough idea of the condition under which mineral crystals are formed. One difficulty is that to make large crystals the molten rock would have to be cooled down very slowly, so that a single experiment would last for thousands of years.

However, a lot has been done. It has even been possible to make small diamonds. This doesn't mean that you had better run round to the pawnbroker's with your diamond tiara when you read this. For so far the artificial diamonds have been dark-coloured ones of the kind called "bort." But within fifty or less years, clear, artificial diamonds ought to be as cheap as artificial pearls. They would be fairly cheap now if the diamond industry were not such a close monopoly that most of those dug up are not put on the market.

But it will be interesting to see whether that particular monopoly will first be broken by science or by Socialism. I think the betting is about even.[1]

MENTAL DISEASE

If you went into a physiological laboratory twenty years ago, you were likely to find a man shut up in an airtight chamber, riding a stationary bicycle with a brake which offered a known resistance. Air was drawn through the chamber at a fixed rate, and by analysing the air leaving it,

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[1] I would take three to one on Socialism now.

physiologists found how much oxygen the man had used, and how much carbon dioxide he had produced.

Sometimes a sheep, pig or rabbit was put in a similar apparatus. The information got was very important for a great many practical purposes. For example the *Thetis* enquiry will, I hope, disclose whether it was properly applied to submarines.[1] But it had one great defect from the point of view of pure science. Nobody knew how much oxygen any particular organ was using.

It was as if we knew how many hours of work were needed to make, say, a pair of trousers, but had no idea what proportion of the labour was provided by shepherds, shearers, spinners, weavers, tailors, and so on. So we did not know whether, for example, the brain used a lot of oxygen, or a very little, still less how to control its usage of oxygen.

To-day the same kind of work is being done on a miniature scale. About sixteen years ago Dr. Marjorie Stephenson at Cambridge began to study the breathing (if one may use this simple word) of bacteria by the same methods which my father had applied to rabbits. Of course, bacteria have no lungs. But some of them use up a great deal of oxygen. Others use none at all, and indeed are poisoned by it. Of course, Dr. Stephenson used thousands of millions of bacteria at a time, for the most delicate methods at present invented could not measure the breathing of a single one, or even a thousand.

Such research has been of medical value. For to understand diseases properly we must be able to grow the different kinds of germs separately. And they need special

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[1] See p. 174.

food, and also in some cases, special gas mixtures in which to live.

Other workers are studying the breathing of small pieces of tissue, for example slices of brain in which the cells are still alive. The most delicate of the apparatus used for this purpose measures the use of as little as a millionth of a cubic centimetre of oxygen. That is to say, it can deal with a group of cells so small that it would take it 10,000 years to use up as much oxygen as a man does in a minute.

What comes out of this in practice? We can find out what kinds of foodstuff the brain oxidises most readily, and what drugs raise or lower its rate of oxidation. This has been the special study of Dr. Quastel, the biochemist employed at Cardiff Mental Hospital. But at the same time that he studied the breathing of slices of brain from dead rabbits he was applying his discoveries to the actual treatment of mental disease.

Two kinds of madness are considerably commoner than the rest. Manic-depressive insanity, or cyclothymia is a disease with ups and downs. At the peak of the wave a patient is talking incessantly, cracking jokes (often quite good ones) and perhaps smashing up the furniture. At the trough of the wave he is weeping and attempting suicide. Schizophrenia, on the other hand, is a disease in which the patient cuts himself off from the real world and lives in an imaginary world of his own, like a professor of economics working out the theory of a society in which there were no monopolies, no trade unions, and no state interference with production.

In manic-depressive disease there are blood changes which run parallel with the mental changes. But probably neither is the cause of the other, both being due to some third cause which we do not yet know. Quastel found the blood changes very useful for following the success or failure of an attempted cure.

Now the methods which are at present most successful in curing these diseases are as follows. The manic-depressive is put to sleep for three weeks or so with drugs, and gets a real rest. He wakes up much calmer, and usually ready to co-operate with the doctor, which is of great importance. Unfortunately, in the early days of this treatment, a number of patients died. The Cardiff workers, by their chemical studies, have been able to cut the death-rate down very greatly.

The schizophrenics are subjected to drugs or hormones which give them convulsions. In some cases, especially if they have not been insane for more than a year or so, this leads to recovery. One may say, very roughly, that the shock wakes them up to reality again. Here, too, there is some danger, but chemical studies can certainly reduce it.

However, very little work is being done on these lines in Britain. The mental hospitals are among the first institutions to feel the pinch whenever there is a wave of "economy," and are generally understaffed with doctors. Actually this kind of economy is quite costly in the long run, even if we neglect the human side of the question. For an uncured lunatic may live for many years as a burden on the community, whereas with the majority of diseases most patients either recover or die within a short time.

Apart from the economic reason, another ground for the neglect of this matter is the widespread disbelief that madness has a material basis, and is more likely to be cured by material means than by words, whether the words are exorcisms to cast out devils or psycho-analysis to disclose hidden complexes. Of course, these verbal methods are sometimes effective, and a quiet life with short and regular hours of work even more so. But a very great deal of madness is likely to be quite intractable until we discover its material basis as we have discovered that of other diseases.

MEDICAL MEASUREMENTS

IN another article, I wrote about the physiology involved in the *Thetis* case.[1] My evidence depended on thinking quantitatively about how human beings work. It is no good just saying that carbon dioxide is poisonous. You could breathe air containing 2 per cent. of it for a lifetime. But if you breathe air containing 6 per cent., you pant violently and become rather ill. A little of it is harmless. Too much of it is a poison. We have a case of the change of quantity into quality.

We are only just beginning to make accurate measurements of living beings. The most familiar of these are, of course, the human height and weight. Men have been measuring and weighing for several thousands of years—in fact, since cloth, grain, and metal became commodities. For a commodity must be accurately weighed or measured.

Another familiar measurement is the pulse rate. But

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[1] See p. 174.

this could only be measured when watches or clocks with second hands had been invented. And they were not invented till they were needed. The monks who made the first clocks did not mind if they were a minute late or early in starting Compline. Accurate clocks were first made for navigation, so that by looking at the sun or a star and a clock at the same time, sailors could tell how far east or west of Greenwich they were.

A rapid pulse is a sign of fever, but it is much better to measure the temperature. This familiar measurement is based on a very recent invention. Sir Clifford Allbutt, who introduced clinical thermometers into Britain, only died fairly recently. And they are now so cheap and familiar that we forget that they involve thousands of years of work, and that a few hundred years ago people did not distinguish between the "heat" of mustard and that of boiling water.

Another familiar medical measurement is that of the blood pressure, or, more accurately, of the maximum pressure in our arteries. The doctor puts a rubber sleeve round your arm, and raises the pressure in it till he can no longer feel or hear the pulse in your wrist. If the pressure is too high, your life is likely to be short, and you are particularly liable to a stroke of paralysis from a burst blood vessel in your brain.

Other measurements are chemical. The composition of your blood is kept extremely steady, because the various cells in a human body, though much more efficient at their jobs than those of simpler animals, can only work if they have the right environment. So blood analysis is becoming important.

Scores of different blood constituents can be measured. But each method for measurement is the outcome of hundreds of years of laboratory work of which very little is heard outside scientific circles. If we want to measure, say, the amount of uric acid in blood, we must first add a chemical which will precipitate a number of other blood constituents, then filter off the precipitate, leaving a clear fluid, add another chemical which produces a blue colour with uric acid, and, finally, compare the depth of colour with that produced by a standard amount of uric acid in a special instrument.

And this is one of the easier blood constituents to measure. However, I think it would take most of my readers several weeks to learn to measure it with reasonable accuracy. One of the first things you must learn is how to wash glass so that it is clean from a chemist's standpoint, which is much more exacting than a housewife's. I well remember the first blood analysis I made in a hospital. If some constituents were sufficiently near normal a man was to be operated on. Otherwise it would be too risky. If my analysis went wrong, I was condemning him to death.

As each new method is devised and finally made accurate, it is first necessary to determine the normal value of what is measured, and its range of variation in healthy people. Then it is studied in people with various diseases. A low blood phosphate is a sign of rickets, a high blood phosphate of kidney disease, and so on.

In fact, living creatures turn out to have a chemical structure just as definite as their physical structure. There are chemical freaks, which may or may not be invalids.

Sometimes we breed them, if the chemical change gives us a new colour in a flower or an excess of butter in milk.

But all this knowledge is still very much up in the air. In a few great hospitals and clinics, the new methods are being fairly thoroughly applied. But though the productive methods in medicine have changed utterly, the productive relations, except for a few details, are what they were centuries ago. We pay the doctor if we are ill, and hope he will be honest enough to cure us as quickly as possible and cut his own fees.

I want to see Socialist medicine, but it is worth noting that medicine is not yet even in the capitalist stage of development. You go to an individual doctor, as your great-great-grandfather went to an individual weaver. The doctors are bound by a professional code like that of a Mediæval guild, which ensures a fairly high standard of work, but slows down progress.

The socialisation of medicine will mean an even greater revolution in the doctor's work than in that of the factory hand. And until medicine is socialised, many of the methods of which I am speaking will remain scientific curiosities of little value to the ordinary man or woman.

MORE ABOUT HUMAN MEASUREMENTS

In former articles, I described how we can nowadays measure many human characteristics besides height and weight, for example the body temperature, the blood pressure, the number of corpuscles or the amount of phosphate in a cubic millimetre of blood. In all these cases we can find an average value..

But this is not enough. The statistician wants to know what is the spread of the population round this average, and the biologist who aims at improving human health wants to know whether the average represents a condition of health, whether large deviations are dangerous, and so on. He also wants to know whether the differences between people are inborn or due to their environment.

Unfortunately, a great deal of nonsense is talked on these matters by people who want our money. You can read advertisements about "what you should weigh if in health" by firms who want your money for drugs which are supposed to increase or decrease your weight. Yet a man with a broad skeleton may be above the average weight for his height, even if he is not at all fat.

Another kind of propaganda deals with the desirability of some physical type, such as the Nordic, with fair hair, blue eyes, a long head, tall stature and so on. This is designed to produce slimming in a different way, by making people spend money on guns instead of butter.

Let us get at the facts. There is an average height, skull shape and so on in each European people. But there is a lot of variation round this average. In fact, a man who is exactly average for every character is as much of a rarity as a dwarf or a fat woman at a fair. And although the average of different European peoples differ, they do not differ much.

Indeed, if we took an average Englishman, Scot, Frenchman, Yugoslav, Dutchman and so on, they would be remarkably alike in height, skull shape and so on—in fact, far more like than a sample of the same number of men from any one nation. That is to say, the variation within a people is much greater than the variation between the different peoples of Europe.

But such facts as this took a long time to find out. Even now our information is extremely scrappy. We know the average head shape and the distribution round the average very accurately in Sweden, because Retzius and his colleagues measured the heads of over 40,000 Swedish Army recruits. We have no information of this kind for Britain, and often our conclusions are based on measurements of only about fifty people.

When this is the case, we need very complicated mathematical methods to tell us whether two averages based on small numbers are really different, or whether the apparently greater variation in one sample than another may not be due to chance. So if we visit the laboratory of a modern physical anthropologist like my colleague, Dr. Morant, at University College, London,[1] we shall find, not only elaborate measuring instruments, but a calculating machine like a hybrid between a typewriter and a cash register.

When it comes to finding out the causes of the differences between different groups of people, things are even harder. About thirty-five years ago my father produced the first accurate method for measuring the exact amount of hæmoglobin in blood from a single drop of it. This determines how much oxygen it can carry, and is low in anæmia.

He started to bleed as many men, women and children

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[1] Now evacuated.

as he could. My sister is said to have terrified another little girl almost out of her life by taking her to our front door and saying "You come in here. My father wants your blood." He showed conclusively that women had a lower average hæmoglobin than men, though most of them are shorter.

For another generation, people thought that this was a natural and unavoidable difference, due to the innate difference between the sexes. Then McCance and others showed that while well-to-do Englishmen get all the iron they need for making blood, a lot of English women, even when they have plenty to spend on food, do not get enough iron to make up for the blood which they lose each month, but make more blood if they get more iron. So there may be no difference at all between the average bloods of well-fed men and women, and it is certainly less than was formerly thought.

Here was a simple physical difference between two groups of people which took a generation to explain. Now, intelligence tests, as they are called, have revealed other differences between social groups, and these are thought by many to be inborn. But intelligence is a vastly more complicated thing than hæmoglobin, and we must be much more cautious in drawing conclusions about what determines it.

One thing is sure: that to get at the truth in such matters, we want both experiments and statistics. Without statistical methods we cannot be sure that we have not been misled by studying a few exceptional individuals, unless indeed we study many thousands. Without experiment we can arrive at facts, but it is much harder to discover their causes. Unfortunately, good experimenters are often bad statisticians, and good statisticians bad experimenters.

But it is worth while asking, before you believe in any general statements about human beings, whether they are soundly based, both on experiment and on statistics. If you ask these questions, you will believe a good deal less and be less likely to skimp your butter either to buy guns or patent medicines.

LAST YEAR'S NOBEL PRIZEMEN

EVERY year the Nobel Prize award committee in Stockholm awards prizes for chemistry, physics, medicine, literature and peace. The prize-money is derived from the profits made in the manufacture of explosives. Although there have perhaps been occasional mistakes, it is generally admitted that the scientific prizes have been very justly awarded in most cases.

This year's prize for chemistry is divided between Butenandt of Berlin and Ružička of Zürich for their work on sex hormones. These substances are responsible, among other things, for the changes which occur in men and animals at puberty.[1]

Thousands of years ago, probably in the Neolithic Age, it was discovered that, if male animals were castrated—that is to say, their testicles removed—they did not develop normally. They are almost always tamer and in

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[1] See p. 62.

some cases very different in appearance. Anyone can tell an ox from a bull.

But only in this century has the process been reversed, so that a boy who has not developed normally can sometimes be enabled to do so. Gallagher and Koch in Chicago concentrated a substance from bulls' testicles which would make the combs of capons—that is to say, castrated roosters—grow again. Their preparations were active. But they were not pure, any more than beer is pure alcohol or opium pure morphine.

Butenandt was the first to obtain a substance of this kind in pure form and determine its chemical composition. Ruzička did the same with other gland secretions which have similar effects. In addition, they have worked on the substances which play a like part in the female sex, both in connection with puberty and pregnancy.

Thanks to Ruzička, these can be made in a factory by the transformation of much commoner substances, and there is now no need to work up 10 tons of male urine, as Butenandt did, in order to obtain a fraction of 1 oz. of one of them. Ruzička has also worked on synthetic perfumes and many other topics in organic chemistry.

Now that these substances have been isolated, there is no excuse whatever for treating human beings with ill-defined extracts of animal "sex-glands," as they are described in advertisements. The pure hormones are far from being cure-alls, but are definitely useful in some cases.

Lawrence of California gets the Physics Prize for his work on atomic nuclei. Rutherford first showed that these are sometimes transformed, so that one element is turned into another—in very small quantities, of course. His pupils, Cockcroft and Walton, accomplished this process by artificial means.

In an electric field of about 500,000 volts, they got the nuclei of hydrogen atoms moving so quickly that they actually penetrated those of other elements and united with them. Thus nitrogen atoms were formed from carbon and so on.

Lawrence invented an apparatus called the cyclotron, which, for some purposes at least, is more efficient than Cockcroft and Walton's apparatus. Many of the new types of atom formed with its use are strongly radioactive. Some of them seem likely to be of as much value as radium emanation in treating cancer. Others are being used to solve biological problems in another way.

Biologists have long wanted to know how quickly the substance of our bodies is replaced. For example, are the bones of an adult composed of the same atoms when he is sixty years old as when he finishes growth at twenty? If you feed an adult rat with sodium phosphate containing radioactive phosphorus, you soon find some in his bones.

This means that the bones are constantly exchanging atoms with the blood. In other words, during life the form of the bones is not like that of the parts of a machine, but is kept steady by means of constant change, like the form of a candle flame or a waterfall.

The Prize for medicine went to Dr. Domagk, who works for the Interessengemeinschaft der Farbenindustrie, the great German chemical monopoly. He found that a red dye called Prontosil, made by Niesch and Klarer of the same firm, would cure mice of infections which would otherwise have killed them.

All antiseptics—that is to say, germ-killers—are somewhat poisonous to men and animals; some of them very much so. Mercuric chloride or iodine are all very well for disinfecting cuts, but, if drunk, will kill a man long before they kill all the germs of disease in his body.

Prontosil and other drugs of similar composition, such as sulphanilamide and sulphapyridine, are dangerous, and have killed a few people. But they have been extremely successful against puerperal fever, pneumonia, gonorrhœa[1] and some kinds of meningitis.

Ewins and other workers employed by the British firm, May and Baker, have produced a particularly useful remedy related to Prontosil. But it is impossible at present to say which of the competing drugs of this group will finally be used. Some of the best are very expensive, because they are protected by patents. Hence doctors may prefer to use a less efficient drug which costs less because it cannot be patented.

This means a sacrifice of life to profits which is inevitable so long as research on drugs is carried out by firms and not by university, hospital or Government laboratories.

It is worth noting that two prizes were given to Germans, although when the Peace Prize was given to Ossietski in 1935 the Nazis objected and stated that in future they would give their own prizes. However, the Nazis doubtless want Swedish money to-day, and it

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[1] This is an exaggeration. There have been a number of relapses in the case of this disease.

would be interesting to know what fraction of the Prize will actually reach Butenandt and Domagk.

Both are organic chemists, concerned with the patterns in which atoms are arranged. The Jewish chemists in Germany were most successful in studying chemical changes, either in the factory, like Haber, who showed them how to fix atmospheric nitrogen in 1914–18, and thus prolonged the war, or in living beings, like Warburg, who found out how cells breathe.

German science has suffered severely from the Nazi revolution, and will suffer worse in future, because the supply of young men and women has been severely cut down. But, especially in the field of organic chemistry, a number of first-rate men still remains.

ATOMS ARE REAL

George Sinfield, the Sporting Editor of the *Daily Worker*, recently asked me how we knew the size and weight of atoms. I told him the answer would take about twelve hours. But I must try to give some of it in this article.

Over a century ago Dalton laid the foundations of our knowledge. Hydrogen and oxygen form two quite different compounds, water and hydrogen peroxide. In water there are eight parts of oxygen by weight for each one of hydrogen; in peroxide there are sixteen. It is a reasonable guess that oxygen is made up of atoms, either eight or sixteen times as heavy as those of hydrogen. When a few thousand compounds had been analysed in this way, the relative values of the atomic weights became pretty certain.

But nobody knew how small the atoms were. And some philosophers said they were only conventions to help our thinking, like parts of speech in grammar or the decimal system in arithmetic. Chemical changes occurred as if there were atoms, but we could never know what matter was really made of. You can read quotations from them in Volume 11 of Lenin's *Selected Works*.

The first measurements which led to anything like the right figure were made by J. J. Thomson at Cambridge about 1896 on the electron, the smallest electrical charge. Later on Millikan measured it more accurately by a simple method. He made a spray of very fine oil drops. Some of them had an electrical charge which could be calculated from the speed at which they moved between two charged metal plates. The charge on a drop was just one, two, three or some whole number of Thomson's units, never a fraction such as one-fifth or two and a half.

But, according to chemical theory, one of these electrical units went through a wire for each silver atom deposited in electro-plating. So the number of silver atoms in an ounce could be calculated, and hence the sizes of all other atoms.

Radium told the same story. It shoots out nuclei of helium atoms with such speed that a single one makes a visible flash when it hits a screen of the right sort of material. The flashes per minute produced by a small amount of radium can be counted, and also the amount of helium gas produced by a much larger quantity in a month. Thus the size of a helium atom is known.

It turned out that the distance between neighbouring atoms in a solid is always about a hundred millionth of a centimetre, generally rather more, but never as much as five times more. In particular, the distance between layers of atoms in a crystal can be calculated. Now, if a series of very fine lines, say, a ten-thousandth of an inch apart, are ruled on glass it has long been known that this glass reflects light in a different way. White light gives a rainbow effect, as with a pearl or a pigeon's breast. But light of a single colour—for example, the yellow light from a sodium street lamp—is only reflected in certain directions.

In these directions the difference between the lengths of the paths travelled by light reflected from two neighbouring lines is just one, two, three, or some other whole number, times the wavelength of the light, and successive waves help one another. In this way, the wavelength of light can be measured.

Now, a crystal behaves in this way to X-rays, reflecting those which strike it at a particular angle. When the Braggs discovered this, they were able not only to calculate the structure of crystals, but the wavelength of X-rays, given the size of an atom. The calculated wavelength agreed well with other properties of X-rays—for example, the voltage in the discharge needed to produce them.

But the finishing touch was put by Siegbahn, who used soft X-rays—that is to say, rays of long wavelength and low penetrating power. He could reflect the same rays at a steep angle from a very finely divided ruled grating, and at a glancing angle from a crystal. The figures which he calculated for the distances between atoms agreed to 1 part in a 1,000 with the earlier figures.

When soap is added to water, it affects its surface properties much more than its bulk properties. The soap molecules form a layer on the surface of the water. Most water has a surface layer of some impurity. Indeed, the first person to make really clean water was a Miss Pockels about 1895. Clearly no layer of a substance can be less than 1 molecule thick. So by cleaning water thoroughly, and then seeing how far a drop of oil will spread, we can measure the thickness of 1 molecule.

If the surface layer consists of protein—for example, egg-white—it can be skimmed off on to a clean glass or metal plate and dried. Then this is done again, and so on. In this way Miss Blodgett got a layer of dried egg-white 1,764 molecules thick on a metal plate. You notice how women beat men on this very fine work. She stripped the layer off, folded it up, measured it with a micrometer such as is used in fine gauging, and found the same thickness, within 1 per cent., as that given by X-ray measurements.

The size of molecules, and therefore of atoms, can also be calculated from the rate at which they settle in a very powerful centrifuge, such as I described in an earlier article,[1] and in literally hundreds of other ways, which all agree pretty well, and give a coherent account of the structure of matter.

It is such a convincing account that if anyone produced evidence which overthrew it I should certainly give up writing for the *Daily Worker* or supporting its policy. For if all this practical and theoretical work was meaningless, scientific thinking would be no use, and among

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[1] In *Science and Everyday Life*.

other scientific thinking, that of Marx, Engels and Lenin.

And if that is so, I may as well start believing the B.B.C. bulletins, sell my articles to Lord Rothermere, and spend the money in night clubs. But as long as I believe that one can get somewhere by rational thinking and action, I shall do my best to persuade others that this is so.

HUMAN PHYSIOLOGY

THE BRAIN

OUR brain is a queer-looking organ with a still queerer history. The part of it which is just inside our skull, where the spinal cord comes in through the hole in the base, is much like the same parts in a fish or a frog, and has the same functions—namely, the regulation of unconscious activities like breathing and the movements of our stomach and intestines.

Above that are parts concerned with posture, half-conscious activities like walking and eating, and the simpler elements in consciousness, such as pain, bodily pleasure, rage and so on. The main part of the human brain, which is relatively much larger in men than in other animals, and therefore most recently evolved, is concerned with other things.

We know a good deal about it, because nowadays people are operated on for brain injuries and tumours while fully conscious. An operation may last for six hours, and you cannot safely keep a man unconscious with chloroform or ether for so long as this. So a local anæsthetic is used, and you can cut the brain or stimulate it electrically, and ask the patient what he feels.

He hardly ever feels pain, for the pain centres are deep down in the old part of the brain. But he may feel pressure, hear sounds, or see lights, and he may make involuntary movements, according to the part stimulated. So a map of the brain can be made, and this agrees very well with a map made on the basis of the arrangement of the fibres, or of experiments on anæsthetised monkeys.

Running across the top of the brain from side to side is the main motor area, a narrow strip of brain whose stimulation causes involuntary movements. An electric shock on the right side of the brain causes movements mainly on the left side of the body, and conversely. The legs are represented near the middle, then the trunk, arms, neck and head. But the representation is on a basis of skill, not strength. The areas of brain controlling the hand, and the organs of speech in the throat and mouth, are bigger than all the rest put together. Just behind this area, and partly overlapping it, is the main sensory area. Here stimulation causes feelings of touch, pressure, tingling, or numbness, in various parts of the body, always on the opposite side.

Further down is the area concerned with hearing, and right at the back, that concerned in seeing. Here injury causes blindness as complete as if the eyes were lost, and often more serious, for memories of things seen in the past may be lost, too. In front of the main motor area is an area controlling the twelve tiny muscles which move the eyeballs in their sockets. These need such careful control that the area of brain concerned is nearly half the size of that needed for all the other muscles.

The ancient senses of taste and smell, which were probably as acute in our ancestors 200 million years ago as they are in us, are located in a part of the brain which is rather hard to get at, as it is overlaid by the more recently evolved parts. But here too stimulation has caused sensations of smell. However, most of the brain is dumb, in the sense that if it is gently stimulated there is no movement or sensation and little disturbance of thought.

Still, we know about its functions from a study of disease or injury. Thus a man with a wound near the sensory area for the hand could tell when and where he was being touched, but could not put the sensations together. So he could not tell a penny from a pencil by feel. A woman who had lost the front part of her brain could arrange and cook an ordinary dinner, but had not enough initiative to plan a larger dinner for guests.

Quite recently it has been found possible to record the activity of the brain without any operation, by recording the electrical changes in it. If wet pads are placed in two different positions on the head, and wires attached to each, an amplifier records rhythmical changes of about a fifty-thousandth of a volt.

The most striking rhythm, of about ten waves per second, comes from the area concerned in vision. It is fairly regular if you shut your eyes and relax. But if you look at something, or even think of something seen, with your eyes shut, the rhythm is replaced by a quite irregular disturbance. All this was discovered by Berger, a German worker. Adrian at Cambridge has given the probable explanation.

The cells in a part of the brain have a natural rhythm. When they are "at rest," they tend to get in step with one another. But when each is playing its special part in thought, movement or sensation this regularity is lost. However, we have not yet reached the stage where we can "decode" the waves, or say whether a person is looking intently at a real thing or at something imagined, as when doing mental arithmetic.

But it is known that the rhythm is altered in light sleep, and almost disappears in deep sleep. And Gibbs, Gibbs and Lennox of Boston found that the rhythm is altered in epileptics, being about doubled in the ordinary type, but reduced to one-third in a type where fits are not so violent. It was this test which was used in a recent murder case to show that the murderer was an epileptic and probably did not know what he was doing.

We are only at the edge of our knowledge of these matters; however, the importance, not only for medicine, but for philosophy, of finding measurable changes in the brain associated with consciousness is obvious. But, since the number of cells in the brain is about 2,000 million, much the same as the number of human beings, and each cell has its own special connections with nerve fibres, the investigation of how the brain works in detail is going to take a good many centuries.

THE TRUTH BEHIND PHRENOLOGY

More than a century ago Gall tried to found a science of phrenology. Various parts of the brain were supposed to preside over different functions. For example, there were regions concerned with language, love, reverence and so forth. What is more, he thought that the shape of the brain could be determined by feeling the outside of the head. So if your "bump" of veneration was well developed, you would be full of reverence, and so on.

This was, at the time, a valuable idea, because it helped people to believe that the mind depended on the brain. And the language centre was rightly located in a region whose injury causes difficulty in speaking. However, you cannot determine the shape of the brain at all accurately from feeling the outside of the skull. For example, inside the forehead there are hollows in the skull containing air. And if these are well developed a man may have a bulging forehead without much brain behind it.

Moreover, the brain does not work in the simple way phrenologists believe. Some parts have fairly straightforward functions—for example, the part concerned with vision. But even a skilled movement, and much more a thought, involves the co-operation of a great many parts.

The dialectical principle on which the nervous system works was discovered by an English doctor of the nineteenth century called Hughlings Jackson. He noticed that when a part of the brain was damaged, two things might happen. One is loss of function—for example, inability to move the hand or to see objects on one's right-hand side. The other is release of function—that is to say, increased activity in some direction.

For example, in old age many people get a stroke of paralysis or apoplexy. But involuntary movements, especially of the hands, are about as common. Everyone must have seen an old man or woman making "pill-rolling" movements of the thumb and forefinger. And in what is called "spastic paralysis" a limb cannot be moved.

But so far from being flabby, it is stiff, with the muscles permanently contracted.

Just the same applies to feelings. In the inside of the brain there is a part called the "thalamus," which is concerned, among other things, with pain and bodily pleasure. Generally it is partly controlled by the outer, more recently evolved, part of the brain. But if this control is relaxed, its functions are exaggerated.

If the fibres uniting the thalamus to the parts of the "new brain" concerned in sensation are destroyed by a burst blood-vessel or an abscess, the patient cannot locate a touch at all exactly on the opposite side of his body. But what the sensation loses in quality it gains in quantity. If he puts his foot to the ground, he may feel "as if he were treading on tintacks," mild heat appears as burning, and so on. On the other hand, a hot-water bottle at just the right temperature "makes me feel happy all over," as one patient put it.

Very roughly, we may distinguish six levels in the nervous system, each partly controlled by the higher parts. Our intestines, and some other organs, have their own private nervous system, and will carry out regular movements when uncontrolled by the brain. If we kill a rabbit and put a bit of its gut in warm salt water of the right composition with oxygen, it will soon start moving and passing half-digested food along. If we put a pin in, the gut will contract in such a way that the pin moves with the blunt end forwards. In fact, our guts have about as much claim as a sea anemone or a jelly-fish to possess mind or intelligence.

The spinal cord, if isolated from the brain, will carry out reflex movements, such as withdrawing a leg if pinched or scratching. These reflex actions form the basis, as it were, of a good many voluntary actions, the spinal cord being regulated by the brain. The third level is the lowest part of the brain, concerned with breathing, heart regulation, digestion and so on.

The next level, in the brain-stem, is concerned with posture—for example, standing—and simple activities like walking. It also contains the centres for sleep, temperature regulation and other functions. Then comes the thalamus, concerned with pleasure, pain and some simple emotions, such as rage. And this in turn is controlled by the main mass of the brain, which is needed for detailed sensation, skilled movement, and thought.

Of course, the distinction is not quite so sharp as I have described. We can get a good idea of how two levels interact by noticing what happens when we speak. When we are at rest, the breathing is regular. The breathing centre carries on without higher control. When we speak, the speech centre in the upper brain takes control of the breathing muscles. But it is not in complete control or we might be suffocated. On the contrary, if the demands of the breathing centre are not attended to, we may have to stop for breath in the middle of a sentence. The art of breath control consists in harmonious co-operation of the speech centre and the breathing centre.

So with thought. It involves many parts of the brain at once. Some people think largely with unspoken words, others with visual imagery, others with imagined muscular movement. But the more we can co-ordinate the different parts of our brain, the better we think. We are only at the very beginning of a scientific study of thought. Such a study involves not only psychological study, but also the recording of electrical events in the brain and a study of the dead brains, both of exceptional men, such as Lenin, and of lunatics and others whose thought processes have broken down.

GLANDS

A YEAR ago George Sinfield asked me to write about the gland treatment which was being given to the Wolverhampton Wanderers. I said I would wait till autumn, when it was more topical. But it wasn't topical when autumn came. The Wolves, like many other features of civilisation, had taken a back seat for the duration of the war. I never found out what the Wolves were getting, as the statement about the gland treatment which George showed me was about as vague as Mr. Chamberlain's statement of his war aims.

A gland is a part of the body which does chemical work, just as a muscle is a part which does physical work. This work may be the separation from the blood of substances which are there already or the making of a new substance. For example, the sweat glands merely remove water and salt from the blood, but the breasts produce casein and milk sugar, which are not found in the blood.

Many of the glands have ducts—that is to say, tubes through which they pour a fluid. Others have no duct, but put back into the blood a substance which they have made. Finally, some glands have both functions. The

Wolves were probably treated with injections of some gland extract.

Some glands pour their products to the outside of the body. Those include the sweat glands and the sebaceous glands, which produce grease for the skin. They are both very small and scattered over most of the body. The tear glands, the glands in the ear which make wax and the mammary glands, each have their own secretion, and the kidneys strain off a variety of waste products into the urine. None of these, except perhaps the kidneys, add anything to the blood.

The gonads—that is to say, the ovaries in a woman and the testicles in a man—not only produce cells whose union makes a new individual, but make chemical substances which influence the growth of other organs and the behaviour of the whole organism. Primitive men made the great physiological discovery that castration alters an animal's build and behaviour, besides making it sterile.

But it was only in the last five years that Ruzička isolated the substance, testesterone, which is made by the testicles and influences the rest of the body. This is one of the group of chemicals called "hormones." Besides the gonads, there are a great many other glands connected with the sexual apparatus, such as the prostate gland, which is often enlarged in old men.

Another set of glands produces the digestive juices. They include the salivary glands in and round the mouth, millions of microscopic glands in the stomach and intestine, and two large glands, the liver and the pancreas or sweetbread, which produce digestive juices and also add substances to the blood passing through them.

Finally, the ductless glands have no function except to make certain substances which they pour into the blood. The pituitary gland lies under the brain and above the throat, the thyroid just where the neck joins the chest, the parathyroids close to it or embedded in it, the adrenals on top of the kidneys. The thymus is found in the chest in children, but disappears in adults.

The lymph nodes, of which there are a great number scattered about the body, are often called glands. In fact, when we speak of swollen glands, we generally mean lymph nodes. They stop foreign particles on their way into the bloodstream along the lymphatics which drain the tissues. This function is somewhat dangerous for them, and they are particularly liable to attacks of tuberculosis and cancer.

Now, if we are to understand the function of the endocrine glands, as all those glands are called which add anything to the blood, we must remember two simple Marxist principles. One is the transformation of quantity into quality. Every hormone produced by a gland is probably a dangerous poison if you have too much of it. Every hormone in the right quantity at the right time is a necessity for health, and at least three are necessities for life.

This has a simple moral. Almost every advertisement of a gland preparation is a swindle. Supposing your pancreas is not secreting enough insulin, you will develop diabetes, which you can generally clear up with injections of insulin. But if you inject too much, you will die in violent convulsions. Only careful tests will disclose the exact amount you need. No one would dare to start a mail order business for insulin in quantities which were of any value. If he did so, he would probably be in the dock for manslaughter within a month.[1]

Recently an American firm advertised a face cream containing one of the female sex hormones. The American Medical Association suggested that it was dangerous, because too much of this hormone will certainly bring on cancer in mice, and might do so in women. The firm replied that the amount of hormone in the face cream was about a millionth of the amount needed to cause cancer. If so, it would be very unlikely to have any effect on the complexion. So perhaps if you buy gland preparations you are more likely to lose your money than your life.

The other principle is that of the unity of opposites. Different glands produce hormones with opposite effects. The pancreas produces a hormone which lowers the blood sugar, the pituitary one which raises it. At first sight, this seems wasteful, but that is how a living thing works. Your limbs are worked by pairs of antagonistic muscles, and normally they are both pulling in opposite directions. If either antagonist went completely limp, the contraction of the other might dislocate your joints. The same principle holds for the chemical action of the glands.

In my next article I shall describe in more detail how some of these glands work, and how they go wrong. But I must ask my readers not to write to me for medical advice. Even if I were a specialist on this matter, which I am not, I could not possibly recommend treatment without actually examining patients. So please do not ask me to prescribe for you.

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[1] A reader has pointed out to me that it would be illegal for another reason.

THE THYROID GLAND, AND OTHERS

THE first of the ductless glands whose function was discovered is the thyroid gland, which lies on each side of the windpipe below "Adam's apple." Most of us have seen people with swollen thyroid glands, a condition called "goitre." It is fairly common in many mountainous districts, such as Switzerland. In England it used to be called "Derbyshire neck."

If the thyroid gland is less active than normal in young children, their bodies grow very slowly and their minds do not develop. In severe cases they cannot even learn to speak. Such children are called "cretins." Adults become stupid and sluggish, their hair falls out, and their face and hands become puffy.

The condition can be completely cured in the adult by feeding sheep's thyroid glands, but children are seldom cured fully, because the condition is rarely noticed until some harm has been done. This would not be so if babies were regularly examined by competent specialists. Out of 1,280 inmates of an institution for mental defectives at Colchester, sixteen were cretins who could have been completely cured, and another thirty-one could probably have been made nearly normal.

In 1914 Kendall isolated the thyroid hormone thyroxine, a compound containing iodine, and in 1927 Harington and Barger made it synthetically. It is an immensely active substance. An ounce of it is enough to keep a person without a thyroid gland normal for a whole lifetime, and the synthetic product is cheaper than the natural one.

Too much thyroxine is even more dangerous than too little. Some patients with goitre make too much. They become restless, thin, and weak, their hearts beat very fast, and their eyes often bulge. This condition may be fatal, but can be cured by removing all or part of the gland. In future it will probably be possible to dispense with the operation by using X-rays and other methods to damp down the gland's activity.

When a man or woman has taken no food for twelve hours and lies down quietly, the heat production is extremely steady, and in normal people is proportional to the body surface. But with too much thyroxine this rate may be raised two or three times. So the patients in a ward for thyroid disease eat much more food than those in an ordinary ward. On the other hand, patients with subnormal thyroids produce much less heat than normal, and need less food.

One cause of goitre is shortage of iodine in the food and water. This was so serious in the American state of Michigan that mobilisation was delayed there in 1917 because there were not enough uniforms with large collars to fit the conscripts' swollen necks. This sort of goitre can be prevented by adding a little iodine to the table salt.

Pregnancy is liable to cause thyroid disease, perhaps because the mother has to make more thyroxine than usual to help the baby's growth; but, apart from pregnancy, women are more liable to it than men. This was especially so some years ago, when thyroxine was sold to make women slim. It is, of course, a dangerous drug, and should never be used for slimming.

Close to the thyroid or embedded in it are the parathyroid glands, which, unlike the thyroid, are necessary for life. If they are removed or diseased the patient dies with terrible spasms, and the spasms which sometimes occur in babies with severe rickets can be cured by a hormone made from animals' parathyroids. If they develop a tumour and produce too much hormone, the bones become brittle, and there are other severe symptoms. Their function is to regulate the amount of calcium in the blood. Luckily, they seldom go wrong.

Another very important pair of glands, the adrenals, lie on top of the kidneys. The outside section, or cortex, is essential for life. If it is destroyed by disease, or removed, the result is a peculiar condition called Addison's disease, characterised by weakness, vomiting, darkening of the skin and death. This can be cured by injecting a hormone first prepared by Swingle and Pfiffner or, better, by a synthetic hormone preparation.

This hormone is now being used before surgical operations to combat the shock which sometimes follows them. It seems, among other things, to prevent leakage of fluid out of the blood, but very little is yet understood about how it acts. However, it looks as if this hormone may run rather short in a number of diseases. If so it is likely to be a really valuable drug.

The middle part, or medulla, of the adrenals is not essential to life. It produces a hormone called "adrenaline" which is poured into the blood during violent effort, and various kinds of emotion. It has a great effect on the involuntary muscles. The heart pumps harder, the blood vessels contract so that the blood pressure is raised. On the other hand, the muscles of the bronchi (tubes leading from the windpipe to the lungs) are relaxed. Thus everything is ready for exertion.

Adrenaline, which can easily be made synthetically, is a most useful drug. If it is injected under the skin, the local blood vessels contract and the skin goes white. A cut can now be made with very little bleeding. If it is injected into a vein it has an immediate, though unfortunately only a temporary, effect on asthma, which is a spasm of the muscles of the bronchi.

The pancreas, or sweetbread, has a double function. It pours a digestive juice into the intestine and a hormone called insulin into the blood. If there is a shortage of insulin, the tissues cannot use the sugar which is present in blood, and this rises to such a level that the kidneys begin to excrete it; so we get diabetes, a wasting disease in which large amounts of sugar are lost in the urine.

Most though not all cases of diabetes can be controlled by insulin, which has to be injected under the skin once or more per day. Unfortunately, insulin cannot yet be made synthetically, so the treatment is expensive. Too much insulin clears all the sugar out of the blood and causes violent and often fatal convulsions.

Diabetes is one of the few diseases commoner among the rich than the poor, and is certainly due to overeating in many cases. Mild diabetes can often be controlled by a suitable diet, but insulin is needed when it is severe. In my next article I shall describe the hormones which are connected with reproduction, and are responsible for many of the differences between the sexes, such as the beard and the deep voice of men.

THE CHEMISTRY OF SEX

If a male animal is castrated in youth, its form and behaviour are different from those of a normal male. This applies to vertebrates, but not to most invertebrates, such as insects, whose different organs are much more independent of one another than ours. And even among vertebrates the effects are different in different cases.

For example, castration makes a great deal of difference to the growth of cattle. A bull is very different from an ox. But it makes much less to a cat. In human beings the characters of the male sex which depend on the substances poured into the blood by the testicles, and are called "secondary sexual characters," include the beard and the deep voice. So boys used to be mutilated so that they could go on singing as trebles and altos in choirs, such as that of St. Peter's in the Vatican.

A castrated male grows and behaves like a normal male if it is treated with testesterone, a waxy substance which was first obtained from testicles, but is now made artificially in laboratories. It is not very soluble in water, so it is best administered by putting a pellet of it under the skin. From this depot it is gradually carried by the blood to other parts of the body. The effects of a single implant last several months.

In men this treatment restores normal sexual instincts and potency, though not, of course, fertility. It is sometimes, but not always, of value in restoring health to old men. The gland-grafting operations which were fashionable (and expensive) in the past, were probably never of great value, and are now definitely out-of-date.

Some other hormones have a similar but less powerful effect.

In the female sex matters are more complicated. The ovary secretes several different hormones. One set, of which the most important is called "oestrone," is responsible for the physical and psychological changes which take place at puberty. In many birds the difference between the sexes is mainly due to female hormones.

If we work on a breed of poultry where the sexes are very different, such as the brown Leghorns, a castrated female looks like a rooster, with feathers of many different colours, and injections of oestrone make a male into a hen-like bird with sober plumage. But in mammals oestrone has less effect.

The ovary secretes another hormone called "progesterone" in large amounts during pregnancy, and without it pregnancy is impossible. Apart from pregnancy, the supply of progesterone is turned on and off again each month, and menstruation occurs when the supply ceases.

Finally, the cortex of the adrenal glands, of which I wrote earlier, sometimes develops a tumour and produces a substance called "trans-dehydroandrosterone," which acts as a male hormone, and may make a woman develop a beard and a deep voice. She becomes normal again if the tumour is taken out.

All the hormones which I have described, and a number of others, are closely related to one another, and to the normal hormone of the adrenal cortex; so that one can be made from another, and all from substances which are easily obtained, and are not themselves hormones, in a chemical laboratory.

They have only been obtained in a pure state in the last ten years, so that we do not yet know much about the details of how they do their work. But we know that they influence a great many, if not all, parts of the body. Thus oestrone makes the skin take up water, and the plump skin of a healthy woman is due to her hormones.

We also know enough to say that only a very small amount of sexual abnormality is due to upsets in the hormone system. On the contrary, a great deal of it is due to social causes. If growing boys are kept separate from girls, as in the "public" schools, where the sons of the rich are sent, it is not surprising that many of them develop abnormal desires.

The way to a cleaner sexual life is through a society where marriage is not put off for economic reasons, where nobody is afraid of having children because they cannot afford to feed them, and where girls do not earn more by undressing in public than by working in a factory.

We do not know how this strange system of hormones evolved, because we can study fossil bones, feathers, scales, and so on, but not fossil glands. But we can get a fair idea of what happened by studying inheritable variation in living animals.

In the first place, a gland may secrete more or less of some hormone or even a hormone which it did not make before, just as a flower may make more or less of a natural colouring matter or else a new one. If the new hormone is useful, say, in accentuating the difference between the sexes, the variation will spread through the species by natural selection.

Secondly, there may be hereditary variation in the way in which the tissues of the body respond to the hormones. Thus oestrone has a great effect on the feathers of the brown Leghorn breed of poultry, but much less on those of the white Wyandotte or the buff Orpington. So in the course of evolution there must have been changes both in the supply of hormones and in their effect on the rest of the body.

Some people think that it is wrong to write or publish such an article as this. I think the truth is very seldom harmful. Boys and girls are far less likely either to make mistakes or to worry over quite natural happenings if they understand what is going on in their bodies.

And it is so difficult to get an account of recent work that teachers of biology who want to enlighten their pupils find it hard to keep up to date. So I only wish that the *Daily Worker* had eight pages,[1] and that I could give more details.

THE PITUITARY GLAND

READERS of my former articles on this subject must have asked how the activities of the various glands are controlled. We cannot answer this question fully, but, even to begin to answer it, we must describe the most remarkable of all the endocrine glands, the pituitary.

In men and women this lies underneath the brain and above the throat, in one of the most inaccessible places in the whole body. So surgical operations on it are very dangerous. But it is quite accessible in some animals—for

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[1] At the time of writing it had been reduced to four.

example, in a frog it can be reached through the roof of the mouth with a dentist's drill.

We owe our knowledge of it partly to the study of disease and experimental removal, but largely to the big Chicago meat-packing firms. They have enormous quantities of glands of all sorts to dispose of, and want a market for them. So they have subsidised a good deal of research on the subject, which has given them almost a world monopoly of some products.

The pituitary produces at least ten distinct hormones. The most useful of these is called "oxytocin." It plays a part in stimulating the womb to contract during birth, and injections of it have saved a good many mothers' lives by controlling bleeding after the baby has been born. Another hormone, vasopressin, causes a rise of blood pressure when injected, and is part of the normal apparatus of control of blood pressure.

When a frog is put on a dark background it soon becomes darker. This is due to the expansion of black cells called "melanophores" in its skin. The expansion of these is caused by one pituitary hormone, and their contraction on a white background by another. These hormones are secreted by a reflex from the frog's eyes.

It is remarkable that the human pituitary produces one and probably both of these hormones. No one has discovered what use they are to men, and perhaps they are just a chemical vestige now of no further use, like the navel and the muscles behind the ear, which enable some people to move it slightly.

These hormones are mainly produced in the back part of the pituitary. The front part specialises in hormones controlling other glands. One stimulates the thyroid, another the adrenals; and without these they do not work satisfactorily, whilst too much may drive them to over-activity.

Another hormone controls the ovary and testicles. Puberty occurs because the pituitary starts secreting the gonadotrophic hormone. If it is secreted too early, children of two or three years old may become sexually mature. Recently Parkes, of London, has used this hormone on sheep.

If the right amounts are injected, a ewe may produce lambs two or even three times in a year. This would be worse than useless in a wild sheep, which would be unable to rear more than one or two lambs yearly. But it is quite feasible, provided the ewes are well fed and the lambs get warmth in the winter.

However, it is likely that this method will not be practicable so long as British agriculture is organised as it is to-day, in small farms. If it is taken up successfully in the Soviet Union, this will not be the first time that British scientists' ideas have proved unworkable under capitalism, but successful under Socialism. Thirty years ago Ramsay suggested that coal seams should be set alight underground and used as a source of gas. This is being done in the Soviet Union, and nowhere else.

Another pituitary hormone stimulates the ovaries to produce the pregnancy hormone, progesterone. The pituitary is needed to start pregnancy, but later on the unborn baby produces a similar hormone in its placenta, or after-birth, which acts on the mother. The pituitary is responsible for the timing, not only of maturity, but of breeding seasons and other periodic events connected with sex.

Yet another pituitary hormone, prolactin, makes the mammary glands swell. It acts on both sexes. Newborn babies of both sexes often secrete a few drops of milk because prolactin has got into their blood from their mother's. Male rabbits injected with it have produced milk.

Quite likely in the future both sexes of cattle will be made to produce milk. But this will only be possible when prolactin has been made synthetically. At present it is very expensive, but it has already had some success with mothers, whom it has enabled to nurse their babies.

The pituitary also produces a hormone which raises the blood sugar and acts as an antagonist to insulin. Most workers on it think it produces a growth hormone. Certainly some extracts of it make rats grow to a gigantic size; and men who grow to a great size and have large jaws and hands are often found to have overgrown pituitaries.

In the skulls of the giant reptiles of the past we can often see the hole in which the pituitary gland lay, and in some cases it must have been as large as the brain. All these facts show that the pituitary gland produces a hormone or hormones stimulating growth, but this may be a secondary result of its action on the thyroid and other glands.

Anyway, it is clear that the pituitary acts as a kind of brain to the other endocrine glands, controlling and regulating their activities. But only three of its ten or more hormones have been obtained anything like pure, and none have yet been made synthetically. The reasons for this are simple.

To do so will need a vast amount of chemical research. And there is very little money available for it even in peacetime, and still less in war. First-rate biochemists are looking for jobs to-day; and the Chicago beef barons do not want hormones made synthetically. And though faulty action of glands is responsible for a lot of ill-health, this will continue to be so until men, or, rather, their rulers, put health before wealth.

A DUTCH PHYSIOLOGIST

I HAVE just spent a week with my colleagues in the Universities of Groningen and Amsterdam in Holland, where I have been lecturing. Although the mobilisation of the Army has taken some students away, university life is nearly normal,[1] and I spent most of my time discussing scientific problems and seeing the research which was being done.

When one sees a new method, whether in science or technology, which achieves big results, one may say one of two things. Either "How clever So-and-So was to think of that" or "What fools people were not to think of that before." For example, the Greeks and Romans had no buttons, but used long safety-pins to hold their clothes on. Anyone can understand how a button works, but it took a very great genius to invent the button and the button-hole.

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[1] In March, 1939. Alas! things are very different to-day.

Metal horseshoes, rudders and collars for draught horses are other inventions which were made during the so-called dark ages, when book learning was at a low level, but the workers were no longer slaves and were beginning to think for themselves. All these inventions made for a lightening of human labour.

I felt a fool when I visited Professor Brinkman's laboratory, for he was doing things in a minute which had taken me several hours to do and cost me rather severe pain. Between 1919 and 1928 I did a great many blood analyses. The blood has to carry oxygen from the lungs to other parts of the body, and carbon dioxide from other parts to the lungs.

So methods had to be found for measuring the amounts of these gases both in the arteries, where the blood flows from the heart to the muscles and other organs, and in the veins where it flows back again. The analysis takes the best part of an hour, and it took me about three months to learn to do it accurately.

One can easily get blood from a vein, and it hardly hurts at all. But arterial blood is another matter. The easiest artery to pierce is the radial artery in the wrist near the base of the thumb, where you can feel your pulse. But, unfortunately, a lot of nerve fibres run along this artery.

Some nerve fibres carry messages outwards from the brain to muscles and glands. Others carry them inwards, and many of these messages give rise to sensations when they arrive at the brain. If you stimulate a nerve anywhere on its course, you feel a sensation as if the organ at the end of it had been stimulated.

Thus if the ulnar nerve in the "funny bone" at the elbow is struck, one feels pain and other sensations in the hand and fore-arm. Similarly when the radial artery is punctured, one feels violent pain in the palm of the hand, probably something like the first stage of crucifixion. So I never really enjoyed experiments where my arterial blood had to be sampled.

Professor Brinkman has simplified things enormously. He noticed that the red blood in the arteries, where almost all the hæmoglobin is combined with oxygen, lets through most of the red light from a neon lamp, while the bluer blood in the veins stops it. So he shines a neon lamp through a finger, and records the amount of light which comes through by means of a photo-electric cell.

To make sure that the blood is flowing through the finger so quickly that it loses hardly any oxygen, he keeps it hot with a hairdresser's machine for blowing hot air. And, of course, a number of other details have to be seen to. In fact, it took him two years to get the method to work satisfactorily.

But it certainly works now. If you give the man whose finger is being illuminated some pure oxygen to breathe, his blood becomes redder (though not visibly so) and a spot of light from the galvanometer moves one way. Give him foul air to breathe, his blood becomes bluer and the spot moves the other way. This apparatus has already led Professor Brinkman to one new discovery about the blood circulation, and it is likely to lead to a great many more. Besides this, it will give a really good measure of the amount of damage done to the lungs by tuberculosis or silicosis.

This is one example of the methods which are now being devised for examining the inside of living things without damaging them. Our ancestors could perhaps study the movements of the human intestines when they watched rebels being hanged, drawn and quartered. We can do so with X-rays.

The functions of the nerves were discovered by severe experiments which involved cutting and pinching them. Now we amplify the electric changes caused by messages passing up or down a nerve fibre, and listen in to the same message which we feel as a touch or a pain.

Above all, we can follow chemical changes inside living cells, such as the taking up of oxygen, by means of colour changes generally too slight to be seen with the naked eye, but easily visible through a spectroscope. This is very important, because it definitely disproves a view which was widely held in the last century, that a living thing, or at least a cell, was in some mysterious way a whole to which the laws of chemistry do not apply. "It is no good using chemical methods to find out what is going on in a cell," they said, "because you must kill the cell to analyse it." This is untrue, because the changes which can be seen to happen in the living cells are the same as those which happen in experiments with materials derived from dead ones.

This opinion is still held, under the name of "holism," by reactionary philosophers such as General Smuts, and applied to the State, which is supposed to be a whole, superior to its parts. If this were true, the State might be healthy though its citizens were mostly miserable. But holism is not true in biology or politics. People who say that they are exalting the State above the individual are really exalting the ruling class above the workers.

So, by shining his neon lamp through his fingers, Professor Brinkman, without knowing it, has not only introduced a new method into medicine, but struck a blow against those philosophies which wish to subordinate the individual to the State.

SOVIET SCIENCE

THE BIGGEST AERIAL BOMBARDMENT

READERS of the *Daily Worker* are able to follow the technical progress of the Soviet peoples. In this series of articles, I hope to tell a little of the scientific work on which this progress is based. I had intended to visit the Soviet Union last autumn, but the war made this impossible. So I have been reading a number of Soviet scientific journals, besides the biological ones which I read normally.

If one reads the attacks on Soviet science in the British Press, one is informed that pure science is discouraged, and that theoretical results may only be published if they conform to Marxist principles. Actually, plenty of work is published which has no immediate application. And sometimes institutes are publicly attacked for not being sufficiently in touch with ordinary life.

The same thing happens in England. But here a laboratory may have its income cut without any reason being stated, whereas in the Soviet Union such matters are freely discussed. If one believes in free speech, one prefers the Soviet method. It is, of course, much easier to combine so-called "pure" and applied science in the Soviet Union than elsewhere, since in England, for example, a university may rightly object to a professor using its laboratories to work for a firm. In the Soviet Union there can be no corresponding objection, since the work will be used for the benefit of all.

In Moscow, Lysenko recently attacked the geneticist Vavilov for being anti-Darwinian. In London Dingle attacked Milne for going back to the principles of Aristotle. Neither Vavilov nor Milne lost his job. But many columns were written in British and American newspapers about the dreadful plight of genetics in the Soviet Union. I only wish that I had the opportunities for research of many of my Russian colleagues.

Certainly, however, Soviet science keeps close to facts of practical importance. For example my colleagues there are able to breed sheep on about the scale that I could breed rats before the outbreak of war. Its other great characteristic is its interest in events as compared with things. About half the Soviet papers on mineralogy seem to be concerned with changes occurring in rocks, whereas workers outside, with some notable exceptions, are apt to regard rocks as if they did not change once they were formed.

A very striking event which is now being studied happened on the morning of June 30th, 1908. An immense meteor fell in a swampy pine forest in the Tungus region of Siberia. There were three or four explosions so loud as to be heard at a distance of 700 miles. A pillar of flame shot into the sky, and there was an earthquake. The Tsar's Government lasted for nearly nine more years. It did not investigate the matter.

The Soviets conquered Kolchak in 1919. In 1921 L. A.

Kulik led the first expedition to see what had happened in 1908. Not till 1927 did he discover the site in latitude 61° N. and longitude 102° E., where the meteor fell. For twenty miles round the centre every tree has been blown down, and many were destroyed at a greater distance. Within a circle of about twenty-five miles' radius, the tops of the trees and the sides facing the centre were burned.

In the centre is a lake covering about two square miles, surrounded by hillocks of peat which have buried the trees. Here fragments of bluish glass and white glistening iron-nickel alloy as big as a fist have been found. But the main body of the meteorite is buried.

The ground in this region is frozen down to a depth of 80 feet, and below that there is wet sand. When the meteor fell, water spouted up through cracks for many miles round, and the area where it hit was flooded and turned into a lake.

In 1938 the area was photographed by air pilots attached to the Arctic Sea service. Attempts have also been made to locate the fragments of the meteor by magnetic methods. These have so far failed, but Kulik still thinks that it consisted mainly of iron and nickel, and not of glass or rock. He hopes to locate the exact spots where the main fragments fell, and to dig them up.

One other such catastrophe has occurred within human memory. This was in Arizona before Europeans reached it. Here the meteor fell in rocky soil and made a crater nearly a mile across. Its fall was recorded in an Indian legend. A number of small oval ponds in North and South Carolina are thought by some geologists to be due to fragments of a meteor or a shower of meteors.

If so, the catastrophe occurred so long ago that all tradition of it is lost. Besides this there are craters ascribed to meteors in Australia and Arabia. Probably a large meteor hits our earth every thousand years or so.

If one as large as the Siberian meteor happened to fall in the centre of London, every building except a few reinforced concrete ones would be destroyed, and eight million or more people would be killed in a few seconds. For houses would be blown down as far off as Chatham, Luton, Guildford and Tonbridge.

I need not say that this event is extremely improbable. It is about as unlikely as that you, your wife and your child will be struck by lightning on three different occasions. Not a single person appears to have been killed by a meteorite for some centuries, though a few wandering hunters may have been caught in the Siberian disaster.

The space between the stars is nearly empty. But it contains particles of matter ranging in size through single atoms to particles of dust and objects as big as large ships. Probably the ordinary "shooting stars" are no bigger than rifle bullets, flaring up because of the huge speeds with which they hit the air. When the Tungus meteor is dug up we may learn a good deal more about these heavenly wanderers.

HOW THE DEAD HELP THE LIVING

In the Soviet Union everyone is expected to be of use to his fellows while alive. And they sometimes go on being so after they are dead. To understand how this is so, we must understand a little about the nature of death.

The old theory of death was that the soul left the body. One moment it was there, the next moment gone. If you watch a person dying, there is often a very definite moment when the breathing stops. That is one reason why life was identified with breathing, and words such as "animal" and "spirit" are derived from Latin words for breath.

After a man has breathed his last, his brain very soon ceases to work, and he is dead as a human being. But some of his other organs are still alive. Unless he died of heart disease, his heart will go on beating if kept warm and supplied with blood. And, above all, some of his cells stay alive for many hours.

Indeed, cells from a chicken have been kept alive for about thirty years when put in a suitable mixture made from blood and other sources of nourishment. They go on dividing, but no one has yet succeeded in making them form a new chicken, as a tiny fragment of some plants or very simple animals will form the rest of it.

Now, if a man were a machine we could use pieces of one man as "spare parts" for another. This is not usually possible. A foot grafted from one rabbit onto another will generally, if not always, die, and the same would doubtless happen with human beings.

On the other hand, blood can be transferred, provided it belongs to the right group. Blood from recently dead people is quite satisfactory, provided they did not die of an infectious disease. However, as healthy people can give blood without danger, blood from living donors is generally used.

There are many causes of blindness. One of the commonest is opacity of the cornea, as the transparent window in the front of the eye is called. Zirm in Germany and Elschnig in Prague were the first to cure this sort of blindness by transplanting part of the cornea from a healthy eye. In Britain, Thomas of Cardiff has further improved their methods.

Dr. V. Filatoff, a surgeon of Odessa, made a number of grafts from cases of incurable blindness where the cornea was transparent. But this involves removing the eye from a living man or woman who has gone blind for some other reason. So he tried using eyes from dead people. The eye is kept just above freezing point for a day or more. Then a round section about ⅛ inch in diameter is taken out of the cornea with a special instrument, a similar hole made in that of the blind man, and the graft put into it.

He was astonished at the success of this method. Using grafts from living people he had only had sixteen successes out of seventy-five. With transplants from a dead eye, he restored the sight of eighty-seven out of 135 cases. Besides this, he operated on another ninety-five cases which he considered hopeless, on the request of the patients, but only succeeded with six.

So far, then, Filatoff has restored the sight of nearly 100 blind people, as compared with less than 200 in the whole of the rest of the world. And in favourable cases he is generally successful, whereas other workers had rarely cured as many as half their patients.

Dr. Filatoff calculates that there are 6,000,000 completely blind people in the world, and 15,000,000 partly blind. He thinks that about 2,000,000 could be cured by this operation. So far about 300 have been. And in so far as war or prejudice prevents contact between Soviet ophthalmologists and their colleagues in other countries, these blind people will stay blind.

For eye surgery is an extremely skilled craft. Every tiny detail counts. In particular, Dr. Filatoff uses as his antiseptic for preserving the eyes a substance called "lysosyme," which is a natural preservative found by Fleming in Britain to be present in tears and in several other natural secretions. It has not been used in the land of its discovery, but in the U.S.S.R. it has been used for preserving, not only eyes, but caviare.

Why, asked Dr. Filatoff, are tissues from recently dead people better than those from the living? He ascribes this to the chemical processes which go on in tissues after the death of the body as a whole, even when putrefaction is prevented. For example, they cause the softening of meat when it is hung.

In order to preserve Lenin's body, as they succeeded in doing, Sbarsky and Vorobiev had to inject chemicals to prevent these changes from going too far. Sbarsky told me that he had been offered a large sum by an American millionaire's widow to preserve her husband's body. But he did not think that millionaires should be treated like Lenin.

Apparently the substances produced in the first phase of the softening process before the cells are actually dead, not merely help the graft to take, but actually help to bring the surrounding tissues back to normal. Filatoff has recently begun to transplant large pieces of skin from dead people, with very favourable results.

Citizen Sackschneider, a metallurgist, burned both his hands. They healed, but the right hand was covered with thick blue scars, so that he could not bend it. On replacing part of this scar with normal skin from a dead man, the remainder became softer, so that the hand could be used again.

At the present moment a number of Filatoff's pupils are experimenting with grafts of all kinds from the recently dead. Probably they are over-optimistic, but they have already got some striking results.

One reason why this has been possible is that people in the Soviet Union are taking a common-sense view of death. Many Englishmen would refuse to allow their wife's eyes to be removed after she had died. But a real Socialist could wish nothing better for himself or those he loves than to go on serving others even after death.

GENETICS IN THE SOVIET UNION

For some years past the capitalist Press has been full of accounts of the appalling condition of genetics, the branch of biology concerned with heredity and similar topics, in the Soviet Union. These attacks emanated mainly from Hitler's friends, who have done and still do all they can to poison relations between Britain and the U.S.S.R. The facts on which this criticism is based are as follows:

Two good Soviet geneticists have taken jobs abroad and refused to return home. One good and two competent geneticists in the Soviet Union have lost their jobs. And the principles of genetics are being attacked by Lysenko and others. Lysenko is, of course, world famous as the inventor of vernalisation, the process by which the germination of seeds is vastly speeded up.

It was quite natural that, before 1930, scientists who were not Socialists should take posts outside the Soviet Union better paid than they could get inside. Even now a professor is rather better off in London than in Moscow, for the gap between a professor's salary and a labourer's is much greater. But if big air raids begin this week,[1] the Moscow professors will have the advantage.

If no British geneticist had ever lost his job, we might look down on the Soviet Union. But Harland, our finest plant geneticist, was dismissed from his post, among other things, for marrying a "coloured" wife, and is now in Peru. Other British geneticists have lost their posts for political and personal reasons.

I have just read a summary of Lysenko's attack on Vavilov, the leader of "orthodox" Soviet genetics. Lysenko was right on some points. Apparently some of the orthodox school thought that once a so-called pure line of plants had been obtained, it stayed pure for ever, and further selection was useless. This idea has been disproved in many countries.

Similarly Lysenko quite rightly attacked the kind of Mendelism which teaches that dominants and recessives occur in the ratio of 3 to 1 in the progeny of hybrids. This is nearly true in some cases. But it is rarely if ever quite true, and if it were always true, natural selection would not take place.

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[1] Second week in July, 1940.

He also brought out some very remarkable examples of what he calls "vegetative hybridisation," in which a plant grafted on to another is permanently affected. These mostly occur in the *Solanaceæ*, the family to which the potato and tomato belong, and are of great interest.

On the other hand, I think Lysenko went too far in several respects. The fact that a named variety of apple or rose, such as "Blenheim orange" or "Ophelia," preserves its main characters when grafted on to different stocks, shows that grafting has less influence in the *Rosaceæ*, the rose and apple family, than in the *Solanaceæ*. It is probably not so universally important as he claims.

Similarly, his attacks on the importance of the chromosomes in heredity seem to me to be based on a misunderstanding. This would be very serious if he were dictator of Soviet genetics.

But, so far from being dictator, here is what he says to his Mendelian colleagues: "The important thing is not to dispute; let us work in a friendly manner on a plan elaborated scientifically. Let us take up definite problems, receive assignments from the People's Commissariat of Agriculture of the U.S.S.R. and fulfil them scientifically."

Very often in the history of science men who made big advances have found that older theories were hampering them, and tried to throw out the baby with the bath water. In the long run such men perform a valuable service to science, even if it turns out that they have gone too far. For they force their more conservative colleagues to re-examine theories and practices which they had taken for granted.

In spite of Lysenko's attacks on Mendelism, a great deal more genetical research is being carried out in the Soviet Union than in any other country except the United States. To take one example, all British sheep are bred to produce wool, which is shorn.

But in the Soviet Union there are also sheep with very tough fleeces suited for coat linings in the north, and sheep with short fleeces giving "Astrakhan," "Persian lamb" and similar furs in the south. These are being crossed, and the results studied. So the Soviet Union leads the world in sheep genetics. It is almost as easy to breed 100 sheep for experiment there as to breed 100 rabbits in England.

Vavilov is the acknowledged leader of what may be called "orthodox" genetics. So far from being silenced as the result of Lysenko's attacks, he has communicated no less than seventeen papers on genetics and related topics to the Moscow Academy of Sciences between January 1st and April 10th, 1940. In England there were two professors of genetics up to 1936. Now there is one. There will be none after September, 1940.

And we are likely to feel the results of this contempt for genetics. A large proportion of our vegetable seeds was imported from Holland, Italy and other European countries. With this supply cut off, we must expect a deterioration in our crops at a time when we need them most.

It is no wonder that our rulers despise genetics. The Soviet Government has doubtless made many mistakes but I do not think it has ever fined a man for producing too big a crop, as the British Government fined a potato grower last year. If our rulers are afraid of overproduction, they naturally do not encourage men who might increase agricultural yields. And whatever may be wrong with Soviet genetics, I wish that the prospects of my science were as bright in Britain as in the Soviet Union.

COLDER THAN THE POLE

BRITISH scientists led the way in the liquefaction of gases. One of the biggest steps was taken by Dewar, who invented the vacuum flask now sold under trade names such as Thermos. It consists of two layers of glass with a vacuum between them and silvered like a mirror.

The vacuum is to prevent heat leaking in through air or other gas. The mirror is to prevent it crossing by radiation. This flask is one of the many laboratory inventions which have proved very useful in ordinary life, but it is mainly used to prevent heat leaking out of tea or soup, not to prevent it leaking in to liquid air.

Air is a mixture of nitrogen, oxygen, and smaller amounts of other gases. When it is liquefied and heat allowed to leak in, it slowly evaporates, like any other liquid. But as is usual in mixtures, some parts evaporate before others.

This principle was first discovered in the case of mixtures of water and alcohol. If you boil beer, most of the alcohol comes off before the water, and if you condense the steam on something cold, you get a liquid containing much more alcohol than the beer.

This, of course, is how whisky and other spirits are made. So don't try the experiment, because if you do you will make a very third-rate whisky, and make yourself liable to a huge fine for having an illicit still. The fact that the same word, "spirit," was used for alcohol and the vital principle which is supposed to leave a man when he dies, proves, by the way, how very materialistically our ancestors thought about life.

But to return to liquid air. If it is left standing, most of the nitrogen comes off first, and what is left behind is not very pure oxygen. This can be further purified, as alcohol can be redistilled; and much of the commercial oxygen used for cutting steel and treating illness is made in this way.

The Soviet Union is right ahead of the rest of the world in separating gas mixtures by this method. They have huge supplies of natural gas underground and are determined to use it as carefully as possible. There are also supplies in the U.S.A. and Canada, but a large amount of them is wasted, for the capitalists who own them are interested in immediate profit, whilst good Socialists will not squander natural resources which cannot be replaced.

So there is a huge laboratory at Kharkov devoted to the study of all sorts of mixtures of liquid gases. The same mixture is kept at various different temperatures and pressures and the gas which comes off it is analysed. In this way, the conditions for the best separation are worked out.

This is the biggest laboratory of its kind in the world, so, though Kharkov is a long way south of London, some places in it are much colder than the North Pole. The coldest place in the world used to be an apparatus in a laboratory at Leyden, in Holland, where helium, the hardest of all gases to liquefy, was first liquefied and then frozen. But I do not know whether this laboratory is still working or even whether it still exists.

In Moscow Professor Kapitza has been working on the design of gas-liquefying apparatus, and he can now liquefy helium in a machine which will stand on a small table, whereas the necessary apparatus used to fill a large room.

The technical knowledge gained in these laboratories is being put to practical use. To take a single example, one might suppose that, because there is plenty of oil there, all the buses in the Caucasian oil-fields would run on oil. But this is not so.

The ground yields gas as well as oil, and oil is easier to transport than gas. So they are trying to use the gas on the spot and send the oil away. Already some buses are being run on liquid methane, one of the gases in the mixture which comes out of the ground.

We have plenty of methane in Britain, where we call it "fire-damp." In fact, thousands of tons of it go up into the air each day from the upcast shafts of our coalpits. It is doubtful whether any large fraction of it could be used even under Socialism, and quite certain that it will not be used under capitalism.

There are three great advantages in storing a gas in the liquid form rather than compressed. You can get much more of it into a given space, you do not need a thick container and there is no danger of a cylinder bursting.

Besides this, methane has a very great advantage over petrol as a motor fuel. If a mixture of air and petrol vapour is too highly compressed before it explodes, it explodes too sharply to give a steady push to the piston. This is called "knocking."

It can be remedied with anti-knocks, such as lead tetraethyl. But mixtures of methane and air do not knock, even at a compression ratio of sixteen to one. This is a considerable advantage in small internal combustion engines.

On the other hand, as heat leaks into the container, the liquid gradually escapes as gas. So it must be used fairly quickly. For this reason, liquid gases are more suited to a planned Socialist economy than to a capitalist system where production and consumption are unorganised.

For you certainly can't hoard liquid oxygen in the hope that its price will rise. So we can hardly expect that the possibilities of gas liquefaction will be at all fully used in British industry until Britain is a Socialist commonwealth. And then we shall have to go to the Soviet Union to learn the most up-to-date methods.

ANIMALS

BEHIND THE SCENES AT THE NATURAL HISTORY MUSEUM

MOST intelligent Londoners have paid a few visits to the Natural History Museum in South Kensington. But they do not all realise that it has other functions besides teaching the public. For example, there is a large block called the Spirit Building, not because it is used for psychical research, but because it is full of dead animals preserved in alcohol, and, indeed, it is so inflammable that no smoking is allowed in it.

The workers in the museum have the task, not only of looking after the collections, but of classifying newly found animals from all parts of the world. Here is a beetle from India, there is a queer-looking beast, looking halfway between a crab and a spider, dredged from the depths of the Antarctic Ocean. Each is handed over to an expert on its group.

He has first to find out whether it agrees in all but the very smallest details with a previously known species. If not, perhaps it is only a variety, like one of the many colour varieties of the currant moth or of some of our common grasshoppers. If it differs still more, it will be classed as a new species of a known genus. For example lions, tigers, leopards, and so on, are put in the same genus *Felis* as the domestic cat. But each species is given a separate Latin name, for example *Felis tigris*, the tiger, and *Felis onca*, the jaguar.

If it is still less like, it is put into a new genus. The same rules hold for plants. If you like, you may call a new species after its discoverer. For example, one bird of Paradise is called *Semioptera wallaceii*, after the great naturalist, Wallace. Or you may call it after someone who did not discover it. Another of these birds is called *Paradisea gulielmi*, after Kaiser Wilhelm II of Germany.

A hundred years ago most naturalists thought that each species had been made just as it now is by God. And the taxonomists, as zoologists and botanists concerned with classification are called, thought they had reached finality when they separated one species from another.

Then Darwin showed that species were nothing absolute, that they had their origin in time, their life, and their death when the last member of a species died. So it might have been thought that the idea of a species had lost its value.

But this was not so. In the first place, it kept its economic value. The system of classifying animals and plants was invented at the same time as the chronometer, because both were needed for the purposes of imperialism. The chronometer was needed for ships to determine their position exactly, and classification was needed for the exploitation of colonies in the early stage when their natural products, such as furs and spices, were their main exports.

Nowadays the exploitation of colonies has reached higher stage. Special varieties of cotton, tea, sugar-cane and so on are bred so as to give the highest possible profits. Foxes are bred as well as trapped. But the taxonomist is still needed to deal with insect parasites on crops and the animals which in turn attack them. He is also proving useful in dealing with problems of hygiene, particularly where insects carry disease.

For example, for several years there have been violent epidemics of malaria in the most easterly part of Brazil. One-tenth of the population died in one valley. This epidemic is due to the invasion of an African mosquito species, *Anopheles gambiæ*, which is more efficient than any of the South American forms in carrying malaria.

No ordinary person could distinguish it from other mosquitoes. This was only possible because taxonomists had spent a lot of time in classifying these insects on a basis of the veins on their wings, hairs on their legs, and so on. It was probably brought over in a French aeroplane from West Africa, and has already spread 200 miles inland. A little is being done to stop these mosquitoes, but not very much.[1]

Of course, if they were men the Monroe Doctrine would be invoked, and they would be attacked with bombers and battleships. But, being only insects, they are not worthy of such honour, and the Brazilians, with some help from the Rockefeller Foundation of New York, will be lucky if they stop them reaching the Amazon Valley and spreading all over South America.

From a purely biological view, too, the species is still a useful grouping. It gives at least a rough guide to

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[1] But see p. 100.

"crossability." It is generally a natural breeding unit, and fairly often different species cannot be crossed, like the hare and rabbit, or give sterile hybrids, like the horse and donkey.

However, this is not always so. Monkeys which are unlike enough to be put in different genera have mated and had young in captivity. And in flies the opposite is true. What zoologists called one species sometimes turns out to consist of several, so like that no human being can tell them apart, but yet only mating with difficulty, and then giving sterile hybrids. On the whole, however, classification is a good guide to crossing. It is also quite a big job. Each year about 2,000 new genera of animals, and probably over 10,000 new species are described. About one-eighth of these are beetles, of which there are already about a quarter of a million species.

So species-making is a nice job for biologists who have an eye for small differences but lack that peculiar quality which makes the good experimenter. Some of them abuse one another with all the zeal of grammarians for breaking various sacred rules which have been laid down for the naming of species. Such rules are, of course, needed to avoid confusion, but a life spent in enforcing them leads one a long way from the scientific spirit.

However, some classifiers try to avoid such quarrels as much as possible, and concentrate on matters of real scientific interest, such as the modifications which a species has undergone in different parts of its habitat and the factors which prevent it from spreading further. Such studies as these can be really valuable, not only for agriculture and animal husbandry, but for human health.

EIGHTY YEARS OF DARWINISM

November 24th, 1939, the eightieth anniversary of the publication of Darwin's *The Origin of Species*, was celebrated in the Soviet Union, but not, so far as I know, anywhere else. There is perhaps a reason for this. According to Darwin, evolution depends on the struggle for life.

This view was acceptable in England in the nineteenth century, when it was believed that economic progress occurred through the struggle of rival capitalists. It is not so popular in an age of monopoly capitalism. But it accords well with Marxism. For, according to Marxism, one of the main motive forces of history is the struggle between classes.

Of course, this is something very different from the Darwinian struggle. The black variety of the peppered moth first appeared in Manchester in 1848. It has replaced the light variety in the industrial districts of England and Germany. This was certainly not because the black moths got together and massacred or starved the light ones. According to Darwinism, the black moths had an advantage as individuals, perhaps in being less visible against smoke-blackened trees and walls.

Darwin was not the first person to suggest that existing animals were descended from simpler ancestors in the past. This was believed by the Roman materialist poet and philosopher, Lucretius, and probably by his Greek forerunner, Epicurus. Professor Farrington of Swansea believes that their doctrines were part of a popular movement which was stamped out in the name of religion (in this case, the worship of Jupiter and other gods) by the Roman State.

Indeed, evolution is a fairly obvious idea if you once realise that nothing lasts for ever. But Darwin was the first person who was able to give at all a convincing account of what had happened and why it had happened. In just the same way, the Greek philosopher, Democritus, thought that all matter was composed of atoms. But it was John Dalton of Manchester who first made it pretty certain.

In each case the reason was the same. Darwin and Dalton had evidence which the Greeks could not have had. There was the evidence of fossils. This first became clear when the order in time of the rocks of southern England and northern France was determined, and it was seen that the remains of the simpler plants and animals occurred in the older rocks.

Now this order was discovered as a result of the industrial revolution which made it profitable to dig long canals. Smith, who first catalogued the fossils found in the different sort of rocks, was a canal engineer.

In the same way, the living plants and animals of the world were catalogued as a result of the voyages of exploration which led to the foundation of colonies by the European nations. When a species was found only on a certain island, related to, but different from, those on neighbouring islands, this made nonsense of the theory that each species was descended from just two or seven ancestors in Noah's Ark.

The facts were waiting for Darwin to put them together. And, indeed, Wallace arrived at many of Darwin's conclusions independently. Both of them were naturalists who had spent many years in observing living animals and plants, and saw how a tiny structure might make all the difference to an animal's survival. Darwin's study of domestic varieties had also taught him how quickly a breed could be changed by artificial selection and something as to how differences were inherited.

Darwinism has never lacked critics. It was violently attacked on religious grounds. Neither Gladstone nor Disraeli, the bourgeois political leaders of England, would accept it. Of course, Marx and Engels did so, as a great step forward, though not as a complete theory. Gradually the first opposition died down, and Darwinism was accepted by the rising generation of biologists.

It explained so much that it was pushed too far. An organ was described in an animal. Then a use was suggested for it and its evolution explained. If an animal was hard to see, its colour was an advantage because it concealed it from its enemies. If it was conspicuous, that was an advantage, because it frightened them off!

Just the same tendency appeared among Marxists, and was criticised by Engels. Marxist writers attempted to explain, not merely the general trend of history, but its tiniest details, on economic grounds. Or they tried to apply dialectics to fishing or portrait painting, where common sense and technical skill were needed.

So about 1900 there was a considerable reaction against Darwinism. This was valuable, because it led to a more detailed study of the laws of heredity and of the actual course of the struggle for life. Naturally enough, Darwin proved to have been wrong on details. So was Dalton.

He thought that oxygen atoms were eight times as heavy as hydrogen atoms, and the formula of water was HO. It turns out that they are about sixteen times as heavy, and the formula is H_2O.

But Dalton's fundamental theory was right. So, I believe, was Darwin's. An increasing number of biologists think so, if only because it is quite easy to alter a population by changing the conditions so as to give an advantage to one type rather than another. And no one has been able to find causes of change which are fundamentally different from those which Darwin considered.

Above all, there is no sign of a guiding principle in evolution other than natural selection, which tends to adapt living things to their environment. Careful study shows, on the contrary, that most spontaneous variations from the normal are harmful, and probably less than one in a hundred passes the test of natural selection.

In fact, Darwin's work has stood the test of time extremely well. One of his sons wrote to me that his father would have been surprised at the smallness of the changes which have proved necessary. His great achievement was to make it certain that animal and plant species (including man) change, and to determine some at least of the general laws according to which they change.

LICE LIKE THE WAR

DURING a war between men and men, it is well to remember that there is another war, against non-human enemies—a war which is being neglected while we fight one another. There is no reason whatever why human wars should not cease. In fact, there is every reason to think they will cease when the progress of Socialism abolishes the oppression of one class or one nation by another.

But the war against other species will go on. Primitive men recognised their enmity with the great beasts of prey—the lion, the tiger and the wolf. I hope that this war will not be fought out completely. Some of the descendants of the Big Bad Wolf are dogs, and are useful members of human society. The cheetah has been tamed and made to work by Africans. Lions, tigers and leopards will breed in captivity, and perhaps their descendants will become tame.

I certainly think the world would be a poorer place without lions and tigers, and I hope that our descendants will not wipe them out. But the louse is a much more dangerous animal than the lion, and I don't see any prospect of taming it. The fleas which pull carts in flea circuses at fairs are not tame, but merely tied up with very fine wire.

Of all our insect enemies, the mosquitoes are the biggest killers. By spreading malaria and yellow fever, they make many tropical regions unhealthy, and a good deal of the so-called inferiority of some coloured races is simply due to the fact that they are chronically infected with malaria and other diseases which lower the vitality of whole nations.

In Britain we have three classes of insect enemies—those which attack our crops, trees and farm animals, and our food, clothes and buildings; those which attack us directly; and those which do not feed on human blood, but carry disease germs. I shall only write about the last two classes.

Lice are a nuisance, though I for one don't feel miserable because I am feeding a few dozen. If you look very carefully at my colleague, Professor Buxton of the London School of Hygiene and Tropical Medicine, you will sometimes notice a curious bulge under his socks. This is caused by a pillbox covered with silk on one side. It contains lice which can put their probosces through the silk and suck his blood, but can't escape through the fine meshes.

I offered to help him in this work, which was carried out to determine, among other things, just how quickly lice breed. But my wife said that if I brought lice into our home she would leave it. There are three species of man-eating lice: the head louse, the body louse, and the crab louse, which lives in the thick hair in the armpits and between the legs.

The head louse and the crab louse lay their eggs on hairs. They can be kept down and ultimately got rid of by washing, but a good ointment helps. Hence the best weapon against them is a bath in every home. Of recent years there has been a big increase in head lice because women who used to wash their hair once a week now have a permanent wave, and don't wash it for months on end. The body louse spends most of its time in our clothes, and lays its eggs there, so its greatest enemy is the laundress.

The main objection to lice is not that they tickle, but that they carry the germs of typhus fever and other diseases from one person to another. During the last war lice caused big epidemics of typhus on the eastern and Serbian fronts, and an epidemic of a similar but milder disease, trench fever, on the Western Front.

It is impossible to prevent the spread of lice unless clothes are fairly frequently washed. That is perhaps why British soldiers in France to-day[1] get no change of clothes! If this goes on much longer, there will be epidemics, and the R.A.M.C. will be kept busy, even if there are no bullets.

The bed-bug is not so dangerous as the louse, though it has been accused of carrying typhus, relapsing and other fevers. I am one of the rare people who are immune to its bites. If you put one on my arm, it has its drink of blood, walks off, and within a few minutes I cannot see where it bit me. But most people swell violently, and children's health may be badly affected.

Bugs like warmth and darkness. They spend most of their time in cracks in walls and furniture, and can only be exterminated by gassing or slum clearance. At present we are beating them on some fronts, but they have just won a series of victories in Kensington, where the installation of central heating in some old blocks of buildings enabled them to crawl right through a block, along the pipes. They may look forward to a great offensive next summer if the black-out is still on. For in warm weather and darkness they will crawl from one house to another out of doors. If bugs could think, they would certainly welcome the human war.

So would house-flies. They kill a lot of babies by

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[1] November, 1939.

spreading the germs causing summer diarrhœa. The death-rate has fallen to one-fifth since 1901. This is because horses have been largely banished from our streets, and therefore flies which breed in horse dung have become much rarer. If petrol rationing brings the horse back, a lot of babies will be killed during the first hot summer.

Altogether, whatever happens in the war between human nations, we may expect some heavy defeats by our insect enemies, following up their first great victory, in which lice carried from the towns by evacuees occupied several country districts. The only alternative would be for us human beings to take the war against insects as seriously as we take the other one.

ANOTHER WAR

WHILE our minds are inevitably filled with the horrors of the present war in Europe, it will do us good to turn them to another war, a war of a kind which would go on—and, indeed, go on on a far bigger scale—if wars between men based on national and class distinctions had been abolished.

In 1930 African invaders landed at Natal in Brazil, the nearest point to Africa, from an aeroplane or perhaps from a French destroyer. They spread along the coast and inland, and occupied about 12,000 square miles of territory. These invaders were a West African species of mosquito called *Anopheles gambiæ*.

There are many different species of mosquito, and the differences in their structure and colour are very small. But they also differ in three very important respects, their breeding habits, the animals which they bite and the diseases which they carry. Sometimes, indeed, there are big differences in one of these respects, with no visible difference in the dead animals.

The most important diseases carried from man to man by mosquitoes are yellow fever and malaria. *Anopheles gambiæ* is a carrier of malaria, and within a year of its landing it was causing severe outbreaks of malaria, which had previously been a relatively rare disease in eastern Brazil.

As Dr. Barber put it: "The invasion of *Anopheles gambiæ* threatens the Americas with a catastrophe in comparison with which ordinary pestilence, conflagration and even war are but small and temporary calamities." An epidemic of smallpox, plague or yellow fever kills thousands of people, but most of the survivors recover completely. But malaria may make a whole population into chronic invalids.

Probably a number of the so-called inferior races of the tropics have been unable to stand up to white men, not because there was anything wrong with them as races, but because their vitality has been lowered by malaria, hookworm and other chronic tropical diseases.

It was not till 1937 that the Brazilian Government woke up to the danger, and in 1939 they were aided by the Rockefeller Foundation, which is spending a quarter of a million dollars on the fight this year.

Mosquitoes lay their eggs in water, and they hatch out as wriggling worm-like larvæ, such as can be found in many water-butts during an English summer. *Anopheles gambiæ* does not breed in running water or in water shaded by trees or rushes. But it will breed in small depressions such as ruts or hoof-prints.

Over 2,000 men are fighting the war. On every road there is a post where cars and trains leaving the infected area are stopped and fumigated to kill mosquitoes. A ten-mile zone is kept non-infectible. It is being mapped by air photography, and every pool or pond in it is being drained or poisoned with arsenic.

From this defensive line, the war is being pushed forward during the dry season, when there is not much water for breeding. Pools are poisoned and houses cleared with sprays of insecticide, and tens of thousands of human patients treated for the disease.

In 1939 the mosquito was driven back some way during the dry season. But the Rockefeller Foundation expects a counter-attack during the rainy season of 1940. If the mosquitoes break through the line, large areas of South and Central America may become chronic seats of malaria so severe as to make decent human life almost impossible. If the line holds, it may be possible finally to exterminate the mosquito.

Similar wars against other mosquito species—for example, *Ædes ægypti*, another African invader of South America which carries yellow fever—are being carried on but with less hope of exterminating the invaders.

When the human race has been united by the abolition of race and class distinctions, we or our descendants will have to fight many wars like this. For a tiny fraction of the cost of the present war, we could abolish lice, bugs, fleas and other insects which carry disease, throughout the whole of Europe.

But this would be useless if they remained in other continents from which they could invade Europe again. The same applies to a great many infectious diseases. Until there is a world organisation for dealing with them, it is useless to try to stamp them out completely in any one country.

I expect that the first century after the human species has formed an effective world community and achieved a reasonable economic standard for every human being will be largely taken up with wars of this kind. They will need just as much heroism and exertion as wars between men and men.

But they will lead to the final abolition of most infectious diseases and a standard of health which we can hardly imagine to-day. No doubt our main tasks at the present moment are to bring about the end of war and capitalism. But while we are doing so, it is heartening to remember that a few men are already doing what, in a happier age, will be the task of millions.

VIRGIN BIRTH, IN RABBITS

A GOOD many religions have stories according to which a virgin has had a child, generally super-human. Now, to a biologist there is nothing in principle impossible about these stories. He can merely say that no such event has occurred under careful observation in the human species, and that before he believes such stories he wants at least as much evidence as would satisfy a jury.

To-day I am going to write of a claim to have produced virgin birth in rabbits. Some readers will say that I am credulous. If I don't believe St. Matthew, why should I believe Dr. Gregory Pincus, of Harvard University? The answer is simple. Dr. Pincus states how he did his experiments. If they are faked, he is a fool as well as a knave.

For they are so interesting that dozens of biologists will repeat them, and if nothing happens he will be hopelessly discredited. For this reason I am prepared to bet about ten to one that his claims are correct, though not much more, because I know that very competent biologists have made mistakes in the past.

Virgin birth, or parthenogenesis, is a normal occurrence in some animals. Some simple animals, such as sea anemones and flat worms, reproduce by budding or dividing in two. Others, such as some snails which are hermaphrodite—that is to say, have both female and male organs—sometimes fertilise themselves.

Neither of these processes is parthenogenesis. This word is reserved for cases where a female animal produces fertile eggs or live young without the aid of a male. It's not very rare in insects. Some female grasshoppers and butterflies, which usually mate, can lay a few fertile eggs without the aid of a male.

In other species virgin birth goes on for many generations, occasionally varied by sex. Thus the common greenflies of plants are all females and produce living young like themselves during the spring and summer. However, once a year or more there is a sexual generation including males and females, generally winged.

In gallflies and other insects related to the bees, unfertilised eggs give rise to males, and fertilised eggs to females. So if there is a shortage of males in one generation, it is made up in the next. Finally, a very few insect species dispense with males altogether. Either there are no males at all or they have lost their function, and flutter round the females in a futile way without mating.

But the apparent economy of doing without males seems to be a failure. Probably maleless species die out because there is no way of combining the favourable characters of different individuals. At any rate, none of the great animal groups has dispensed with sexual reproduction.

If fertilisation is a necessity in most species, this is not because of any intrinsic need for it, but probably because it is an essential for rapid evolution, and species which do not practise it are left behind in the struggle. When this was realised, many workers tried to induce development in the unfertilised eggs of species which normally reproduce sexually. This was first done successfully on a large scale with sea-urchins by Loeb, who found that development began if the eggs were put for a few minutes in sea-water containing extra salt and then returned to normal sea-water.

Later a few successes were scored with frogs. In both frogs and sea-urchins the eggs are fertilised outside the mother's body. In higher animals they are fertilised inside, and may then develop outside it, as in birds, or inside, as in mammals, including women. So, to make them develop, they must be removed from the mother's body.

Pincus used several methods. His most convincing one was this. A female rabbit is injected with a hormone which makes her shed eggs from the ovary. She is then killed and dissected. The eggs are too small to be seen easily with the naked eye, but can quite easily be seen with a hand lens. They are heated to 117° F., which is well above body temperature, for three minutes, or put in strong salt solution for rather longer. These drastic treatments start some of them developing.

Then another female rabbit, who has been treated with the appropriate hormones, is anæsthetised, and the eggs from the first one are placed in her womb, where they develop. At least five rabbits have been born alive after such experiments. All were females, and one has had young herself in the ordinary way.

It is intelligible that this process should give females only. For male mammals, including men, possess a chromosome in each cell which is absent in females. It has not yet been possible to induce pregnancy in a virgin rabbit without an operation. It may be so in future, and it is conceivable that the same may be possible in the human species.

If so, it would probably be of no use whatever. Nevertheless, experiments of this sort are of value for two reasons. They help us to take a clean common-sense view of facts which are generally veiled behind mysticism, on the one hand, or dirty jokes, on the other. And an understanding of the physiology of pregnancy should help to save the lives and health of human expectant mothers and unborn children.

CHANGE

METAMORPHOSIS

I SOMETIMES wonder whether the present leaders of the Labour Party have watched a mayfly emerging from the skin of its larva, or a butterfly from its chrysalis, things which any keen naturalist can see in the summer if he can get out of the town and keeps his eyes open. For these are examples of sudden and violent changes in animal development, as different from the slow growth of a child into a man as a bomb explosion from the boiling of a kettle.

And there are sound theoretical reasons, as well as the practical example of October, 1917, to believe that the change from capitalism to Socialism must be sudden. Almost every animal has a sudden change at some stage or other in its life history. Among the most conspicuous are those of insects.

The more primitive insects, such as grasshoppers and cockroaches, moult about half a dozen times, roughly doubling their size at each moult. But the changes are not very striking. If you look at a young grasshopper, you find a general resemblance to the adult form, though the wings are stumpy and useless for flight.

But the higher insects are quite unrecognisable when young. Butterflies and moths start life as caterpillars; ants, bees, wasps and some flies as grubs. Others, including mosquitoes, dragonflies and mayflies, are quite complicated, wingless creatures living in fresh water. Mosquito larvæ look like swimming worms; young dragonflies are more like lobsters.

The process of metamorphosis is now being studied by a number of biologists. When a caterpillar is going to change into a butterfly, its skin hardens, and then a most peculiar thing happens. Most of its internal organs are destroyed by phagocytes—that is to say, wandering cells such as we find eating bacteria in the pus of an abscess, and dissolve into a sort of creamy pulp.

But a few small sets of cells remain. These are the rudiments of the adult organs, such as wings and legs, and they grow very quickly at the expense of this pulp, until there is an almost completely new creature. For nine-tenths of the caterpillar actually dies in the process of metamorphosis. Indeed, the change is rather dangerous, like birth in the human species, and kills off a certain number of caterpillars.

Metamorphosis depends, among other things, on a gland in the caterpillar's head, whose secretion controls it, as the secretion which the testicles pour into the blood controls the change of a boy into a man or a calf into a bull. The details are being worked out in particular by Dr. Wigglesworth, of the London School of Hygiene, who at one time used to experiment on me, taking samples of my blood after I had breathed various gas mixtures, but now prefers to work on something smaller, preferably bed-bugs and related insects. Apparently this gland produces a stuff which makes an insect metamorphose. Another gland prevents this process from going too far until the right moment. So, instead of taking on the adult form it merely moults its skin. But by grafting these glands it has been possible to make miniature adults which had metamorphosed too soon and also immature forms which were bigger than ordinary adults.

Other animals undergo even stranger changes. Many snails begin life as symmetrical animals, and the sudden change to asymmetry takes place in a few minutes. A barnacle, which spends its adult life attached to a rock or a ship's bottom, begins life as a freely swimming animal somewhat like a young shrimp, and then sticks on to a solid surface with its head, and spends the rest of its life kicking food into its mouth with its legs.

The tadpole, as it develops into a frog, scraps its tail, gills and other organs which it no longer needs. But the change is not so quick as in an insect. Human beings also go through an astonishing series of changes before they are born. We all had tails about six months before we were born, and later developed a woolly coat, which we moulted.

But the most sudden changes occur at the moment of birth. Before it is born, a baby gets all the oxygen which it needs from its mother. Its heart pumps impure blood out through the navel string to the placenta or after-birth, where it picks up oxygen and food from its mother's blood, and gets rid of waste products, though there is no actual exchange of blood. The pure blood then flows back through another vessel in the navel string.

When the baby is born the midwife ties the navel string, and it begins to breathe. Before it was born only a little of its blood went through the lungs. There was a by-pass called the ductus arteriosus. Within a few minutes this shuts, and all the blood goes through the lungs at each circulation.

Sometimes this by-pass or another by-pass between two of the heart's chambers does not shut. In this case the baby often dies. But sometimes it lives. Occasionally a "blue boy" is shown at a fair, in whom a large fraction of the blood does not go through the lungs. Such people are chronically blue, like an arm whose circulation has been temporarily blocked by a tight bandage. They are always weak, but can sometimes live for some years.

Occasionally a metamorphosis can be put off. But usually a failure to make the change at the right moment leads to death or invalidism. Let us hope that we do not delay for too long the change from the caterpillar of capitalism to the butterfly of socialism.

CALENDARS

For many years there had been no real night in our cities. The black-out has made townsfolk welcome the moon as countrymen had long done. And the long nights are not only a nuisance, but a positive danger to life.

So we can celebrate Christmas, not only because it is the reputed day of Jesus' birth (though the early Christians were quite doubtful as to its date), but because the days are getting longer. According to Bede, the Angles celebrated it on the first day of the year before they became Christians; and the worshippers of Mithras kept the birthday of the sun on December 25th.

In our modern calendar the shortest day is December 22nd. But in reality Christmas Day and New Year's Day both represent attempts to fix the shortest day, which failed owing to the difficulty of designing a calendar.

A small primitive community did not need a calendar at all. The great days of the year, such as those of sowing in the spring and harvest in the summer or autumn, depended on the weather. But a larger community needs a definite calendar. Everyone for many miles around had to know the date of a fair in a city well beforehand. And when people began to work for others instead of for their own families, regular days of rest, such as the Jewish Sabbath, became necessary.

Now, Nature gives us three periods, the day, the month (from one new moon to the next) and the year. Calendar-making would have been very simple if there had been a whole number of days in the month and year and a whole number of months in the year.

But this is not so. There are about 29¾ days in a lunar month, 365¼ days in a year, and 12⅓ lunar months in a year, but these fractions are not exact. So most ancient calendars were based on lunar months. Twelve of these made a year of 354 days, and every third year or so an extra month was added, so that the seasons fell roughly in months with the same names in different years.

The Jewish religious calendar is still regulated in this way. So a Jewish year may be as short as 353 or as long as 385 days, and the Jewish New Year may fall in September or October. On the other hand, Mohammedans, who also use a series of twelve true or lunar months, do not put in an extra month. So Ramadan, the month of fast, corresponding to Lent, is at no fixed season, but begins about eleven days earlier each year.

Our own calendar months are conventional, and have nothing to do with the moon. Their arrangement is a matter of chance. The Romans used lunar months, and it was the job of the *pontifex maximus*, or high priest, to put in an extra month as needed. He used this power to postpone elections if he approved of the magistrates, or to put them forward if he did not.

By 46 B.C., the calendar was out by three months, so Julius Cæsar, who was dictator of Rome, made one year last 445 days, and fixed the present calendar to prevent such things happening again. Unfortunately, his astronomical expert, Sosigenes, thought the year had exactly 365¾ days, and fixed a leap year in every fourth year.

This makes the year eleven minutes too long on an average. So by 1582 the calendar was wrong by ten days, and Pope Gregory XIII directed that the day after October 4th should be reckoned as October 15th. But the countries where the State Church was Protestant or Greek Orthodox would not follow the Pope's lead.

Britain did not make the change till 1752, and in Russia it was one of very many changes introduced by the Soviet Government. That is why the anniversary of the Revolution which occurred in October, 1917, according to Julius Cæsar's calendar, is now celebrated in November.

Pope Gregory improved the Julian calendar by abolishing leap years on three out of every four hundredth years —for example, in 1700, 1800, and 1900, but not A.D. 1600 or 2000. Actually Asia was ahead of Europe in astronomy at that time, and the Persian astronomer and poet, Omar Khayyám had proposed a still more accurate system. But Gregory's will not be a day out till A.D. 4000.

Long before that time I expect that we shall have a more rational calendar. The main objections to calendar reform at present come from religious organisations, which object, for example, to a fixed Easter. However, it is only fair to admit that the Catholic Church took the lead in calendar reform in the past.

To-day we take the calendar so much for granted that we sometimes forget that it is a human institution with a history, and that even the year can be reckoned in several different ways. For practical purposes, we use a year in which the shortest day falls on a fixed date.

But astronomers use the sidereal year, which begins when the sun is in a fixed direction from the earth. This is 20¼ minutes longer than the ordinary or solar year. The ancient Egyptians started their year when the star Sirius was first visible at dawn, so it was a sidereal year. In consequence, according to their calendar, the Nile flood arrived about a day earlier each century, on an average. Some Indian calendars are also arranged in this way.

We need not worry because the year is nothing absolute. That does not mean that it is a human invention like the calendar. It is a natural occurrence, and therefore has no sharp boundaries. Our ancestors began with too simple a theory of it. This has constantly had to be improved because it did not give a calendar in full agreement with the seasons.

We now know enough about science to be fairly sure that no theory will ever be quite exact. But we continually get nearer to the unattainable goal of absolute truth

ICE AGES

It is now[1] no longer a secret that the British weather has recently been cold. But a cold snap measured in weeks is relatively unimportant. Geologists tell us of cold snaps which lasted for tens of thousands of years, during which most of England was covered with a sheet of ice. The existence of these ice ages was deduced from a number of facts. For example, boulders of granite of a kind only found on Shap Fell in Westmorland have been found dotted about central and southern England, and many of the details of our landscape can only be explained by ice action. However, the evidence for the Ice Age was circumstantial, though no geologist doubted it.

Recently two new pieces of evidence have turned up. An American scientist, Piggott, lowered an apparatus to the bottom of the Atlantic which shot a metal tube down into the mud, and fished up a sample of shells of microscopic animals similar to those which form chalk.

He found four distinct layers of skeletons of types now only living in the Arctic, and deduced that the Atlantic had been very cold, and perhaps frozen over, during four long periods, corresponding to the four ice ages which

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[1] February, 1940.

geologists needed to explain their findings on land.

Last year Benfield, a British geologist, got much more direct evidence. Everybody knows that "it is warmer underground." Deep mines are unpleasantly hot. But their temperature may be above that of the rock, owing to oxidation when air gets at pyrites and other minerals, or it may be below it, owing to ventilation.

The best figures for rock temperature are obtained from bore holes into which air does not penetrate. A number have been made of late in Britain in unsuccessful attempts to find oil, and temperatures taken. Generally the temperature is about 76° F. at a depth of half a mile, as compared with an average of 51° F. at the surface.

Benfield then went on to calculate the rate at which heat is flowing upwards. He took blocks of rock, where possible from the actual bores, and measured the amount of heat flowing through them per hour for a given temperature difference. Then he worked out how much heat was rising per square yard at different depths.

The result was surprising. The heat flow at a depth of half a mile is about a third greater than at a depth of a few hundred feet. That is to say, the top half-mile of the earth's crust is getting more heat than it gives out, and is therefore warming up.

His figures agree well with the theory that, until 10,000 years ago, the surface of England had been at freezing point for a long time. The surface has warmed up, but the intermediate depths are still cooler than they will be when they have had time to get warm by heating from below. On the other hand, South African bore holes, some nearly two miles deep, show no sign of an ice age.

Better measurements will no doubt furnish a more exact date for the melting of the ice sheet. The history of English weather in the last 10,000 years has been followed by quite different methods. A notable contribution has recently been made by Godwin and Clifford.

They studied soil sections in the Fen district and notably the soil which had accumulated under various meres since drained, such as Whittlesey Mere, south of Peterborough, which was the second largest lake in England till it was drained in 1851. About 10 feet of soil have been laid down since the last ice age, say 1 foot per 1,000 years.

Most of this soil consists of peat. Some of it is so rich in plant and animal remains that it stinks when dug up, and is locally known as "devil's dung." Seeds, fruits, roots, leaves and, above all, pollen grains of many different plants were identified, and changes in the climate were followed by changes in the vegetation.

For example, the replacement of pine and birch by oak and lime trees meant a warmer climate, while blown sand tells of dry weather, moss and reeds of rainy periods. There were also a few human remains to tell us what kinds of tools our ancestors were using.

The conclusions are as follows. Just after the Ice Age there was a cold period; then a warm dry one till about 5500 B.C. This was followed by a period much wetter and warmer than now. During this time the first bronze tools began to replace flint, and the sea covered most of the fenland, laying down clay with sea shells.

From about 1500 B.C. to 500 B.C. the sea retreated and the weather was dry and warm. Then came a cold and wet period, including the Roman invasion. With the Anglo-Saxon invasion came drier and warmer weather, and in the last six centuries the weather has been somewhat worse again.

Only in the last 300 years have men begun to drain the fens in a systematic way. Probably in each age till then men thought that the countryside had always been as they found it, at least since the Creation or Noah's flood. If so, they were not as ignorant as people who believe to-day that humanity will always be, as it is now, divided into warring classes and warring nations.

For an ice age lasts for 50,000 or 100,000 years, and the different weather phases since the ice melted generally lasted for 1,000 years or more. But historical periods, such as those of feudalism and capitalism, only last for a few centuries, and we are now very near the end of the capitalist period.

If we go on thinking—as some people still do—that class distinctions and war are part of the eternal order of Nature, we are naturally depressed by the horrors going on around us. If we realise that change is part of the very being of Nature and society, we can fight against these horrors with every hope of success, and be proud to play our part in the great change through which humanity is now going.

THE BIOLOGY OF SPRING

SPRING will soon be here. Seeds will be sprouting, buds bursting and birds beginning to build their nests. For ages people have taken these things for granted, as they took the order of the seasons. But only a few thousand years ago they started asking why they happened.

Perhaps before that children asked and were told that the gods had made things that way. But some Greeks tried to give a different sort of answer: 2,500 years ago the historian Herodotus suggested that the sun went south in winter to avoid the bad weather. We see now that he was putting the cart before the horse. We have cold weather in England because the sun is low in our sky and high in the sky of Australia, not the other way round.

We know this is the right explanation because we have a very exact theory which tells us the direction of the sun at any moment, and this has nothing to do with the weather. We know it is a good theory, because it works in practice, even if Herodotus' theory appeals to our emotions more, and we think that if we were gods or even rich men, we would go south in winter.

Only lately have we begun to find out why plants and animals have an annual cycle. Here, too, our knowledge is practical knowledge, because it enables us to predict and to control what plants and animals will do. Plant seeds mostly depend on temperature and moisture to start them sprouting. But it is not sufficient that they should be warm and damp. Some wheats, if they are stored through the winter and sown in spring, will not germinate in time to give a good crop, especially in countries where the summer is very dry.

This does not matter in England, where we can sow them in the autumn. But in the Soviet Union the winters are so cold in many parts that only very tough kinds of wheat can be sown in autumn. And Lysenko has found out how to prepare the seed so that it will germinate at once on sowing in the spring.

The process of vernalisation, as it is called, is simply an artificial winter, with moderate cold and wet. It can be carried out inside a barn, and the precise temperature and number of days cooling needed have been worked out for different varieties of wheat. This has led to a big increase in wheat production in many parts of the Soviet Union.

For many animals and plants light is more important than temperature. For example, ferrets will not normally breed in winter. This is not because it is too cold, for they do not breed if kept in a warm room. The deciding factor is the length of the day.

If a bright light is turned on every evening, so that the effective length of the winter day is twelve hours or so instead of eight, the ferrets will start breeding in December instead of March or April. Many birds behave in the same way.

In birds, not only breeding, but migration, depends on the length of the day. The most striking experiments on this question have been done by Rowan in Alberta. He worked on a local species of crow, which generally goes south each autumn. He kept his crows in a cage which was illuminated each evening, so that the days did not get any shorter. When the crows were treated this way, they did not migrate southwards if released. In fact, some of them went north.

He marked their tails with yellow paint, and the yellow-tailed crows were seen, and some of them trapped or shot, in sufficient numbers to allow him to make maps of their journeys. Two years ago he was in London, and was able to show that starlings which nest on the National Gallery and Marble Arch mature earlier than those in the country. He put this down to the street lighting. If this is true, the black-out ought to have brought them back to normal, but I don't suppose anyone has investigated the matter.

Probably many other birds migrate for the same reason. For example, when the swallows come to England it will be because the days are getting too short for them in South-west Africa, where they spend the winter. In the case of Rowan's crows, the migration was certainly bound up with their sexual life, for they did not migrate if castrated.

It is very likely that the swallows come north for the same reason, that is to say because they are getting near their mating season. But of course this does not tell us why they want to fly in one direction rather than another, or how they find their way to their old homes. These are still unsolved problems, but perhaps Rowan or some other worker who combines his experimental attitude and his interest in birds will solve them later on.

The length of day also governs the flowering of many plants. For example, maize is a "short-day plant." However early we sow it in England, it won't flower in the summer out of doors. But it can easily be got to flower if it is grown in a greenhouse and the daylight is shut out about 5 p.m.

Out of doors the cobs seldom ripen till so late in the year that in England they are often nipped by frost. So maize is little grown in this country. On the other hand, many of our summer flowers are "long-day plants" and will not flower in the tropics even when grown in fairly cool, mountainous regions.

But each plant has its own requirements of lighting and temperature, just as it grows best in some particular soil. So the biologists have still a very great deal to find out about what makes the flowers bloom and the birds sing.

DEMOCRACY

SCIENCE depends on exact observation, exact measurement and exact thinking. In our thinking we use words or other symbols, and it is important that these symbols should have a definite meaning. If we want to measure fluid exactly, we must use a glass or quartz vessel whose volume stays nearly constant, and not a rubber bottle which stretches.

In just the same way, a word must keep its meaning, so far as possible. Ordinary words change their meaning very quickly. The word which we use for human children used to apply only to young goats, and slang words like this may become official later on. For example, the French *tête*, meaning "head," is the Latin *testa*, which meant "pot," but was used for "head" by the workers in Roman Gaul.

To avoid this, scientists invent words and phrases like "coryza" for a common cold, "sodium chloride" for common salt, "odonata" for dragon-flies, and so on, hoping that they will keep their own meaning. This will ensure that readers in foreign countries to-day or in

Britain 100 years hence can be clear as to what British scientists meant in 1939.

One of the words which has changed its meaning a very great deal is "democracy." This word is being so misused to-day that I am going to desert natural science for a while to write about it. When the Greeks began thinking about politics twenty-five centuries ago, they invented a whole series of words to describe different sorts of government. For they lived in hundreds of independent cities. And as they all spoke nearly the same language, a man could travel from one city to another and compare them. A lot of these words, such as "tyranny," "oligarchy" and "democracy," have come down to us, but all have altered their meanings.

A democracy meant a city where the power (*kratos*) was in the hands of the poorer section of citizens (*dēmos*). Sometimes they had come into power by revolution under a people's leader (*dēmagōgos*), sometimes by constitutional methods. Of course, the citizens were not the whole people. There were always voteless aliens from other Greek cities, and slaves who were sometimes Greek war-prisoners, but usually from outside Greece.

However, a great many of the citizens were skilled workers, even if they owned a slave or two to help them. And slavery had its good side. For example, in Athens during its most democratic period the police were slaves, because their job was thought to be a dirty one unfit for freemen. And slaves could only give evidence under torture, though this was often not at all severe.

But this law made it quite certain that the police would not bring frivolous accusations against citizens. In fact, I can imagine that certain comrades who have recently been summoned for obstructing the police would not shed too many tears if the Athenian law were introduced in Britain!

In a Greek democracy, such as Athens, all the citizens met together, and this popular assembly made the laws, determined policy, had generals executed, and so on. Even so, they realised that individuals might become too powerful, so, instead of electing their rulers, they chose most of them by lot for one year's service.

And if in spite of this anyone became too powerful there was a ballot called "ostracism," in which a man's name was written on oyster shells (*ostraka*) because paper and parchment were too expensive. If any man's name was written on a majority of the shells he was exiled for ten years.

The Greek cities never managed to form a federal government, so they were conquered, first by the Macedonians and then by the Romans. In the Middle Ages the English kings started summoning representatives of the bourgeoisie in the cities and the small landlords in the shires to the House of Commons, and it gradually gained power.

To-day, a state which is governed by elected representatives of all citizens is often called a "democracy." In this sense at least, America and France[1] are democracies, though Britain, with its hereditary monarchy and peerage, is not, and women do not vote in France.

But if you could raise an ancient Greek from the dead

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[1] This was written before the arrest of the Communist deputies, which was the first step towards the abolition of democracy in France.

and ask him whether, say, France was a democracy, he would certainly say, "No." He would think it a splendid thing that all Frenchmen were united into one state, and very probably welcome the absence of slaves. But he would add that the officials had far too much power for a democracy, and that, if the people of a town could not get together and arrange their own affairs, this was most undemocratic.

But further east he would find something much more like Greek democracy. "A Soviet," he would say, "is very like the popular assembly in a small Greek city." And, besides this, he would see that the Union of all these Soviets was governed by something like the British Parliament.

In fact, the Soviet Union is the only part of the world where democracy exists both in the Greek and the English senses of the word. It is often stated that the Soviet Union is not a democracy in the British sense, because very few elections to the Supreme Soviet are contested, so the electors have no choice between candidates.

In the first few centuries of the House of Commons contested elections were rare because each Member represented only one class. Later a struggle developed between Whigs, representing the rising and at that time still progressive bourgeoisie, and Tories, representing the landlords. Still later the Labour movement began to put up candidates.

But with the end of the class struggle it is natural that electoral contests should also become unusual. The important point is that on the whole Ukrainian peasants should be represented by an Ukrainian peasant, and

Caucasian oil-workers by a Caucasian oil-worker, as is the case.

Such is part of the history of the word "democracy." To make it a reality once more, we must try to give it back some of its original meaning. And we must not believe that, although we have a measure of political liberty, we ourselves are living in a democracy.

OPINIONS OF DEAN INGE

DEAN INGE provides[1] the readers of the *Evening Standard* once a week with a philosophical article suited to the political views of its proprietor and advertisers. Occasionally he trespasses into science, as he did on January 1st, 1940. As a Dean, he is no doubt entitled to write of God that "He may be, and probably is, aware of events as earlier or later."

I am interested in his uncertainty as to the extent of divine omniscience. But when he tells me that "All mathematical calculations are theoretically reversible. It does not matter from which end you begin. . . . The past and the future are both real. . . . We travel through time as we travel through space," I must really protest.

Such philosophical ideas are very useful if you want to put over the idea that "the thing that has been is the thing that shall be," "the poor we have always with us" and so on. They lead to the conclusion that we had better not listen to dangerous fools who tell us that progress is a reality and that we really can make the world better.

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[1] These articles have now ceased.

Unfortunately, they are wholly out of date as science. Three hundred years ago men were beginning to understand about the simplest machines, such as levers, pulleys and pumps, and to calculate how they worked. Now, simple machines can work backwards as well as forwards. This greatly simplifies the mathematics needed to predict what they will do. And the same mathematics were found to describe the movements of the stars, including the earth, with sufficient accuracy for practical purposes.

Newton believed in a creator, but he did not see any miracles going on around him. So he thought that the world was a great machine, which God had made and set going. And the mathematical theories based on this view of the universe worked very well, provided they were not applied to changes of quality.

You can calculate what happens when a stick bends. If you let go, it will spring back to its original shape, or nearly so. But when it breaks, things are very different. And if your mathematical equations tell you that the two halves might fly together and join up again, that merely shows that they are bad mathematics.

Modern science is becoming more and more based on the theory of probability. We cannot at present make sufficiently accurate observations to say whether a particular water molecule in a kettle will fly off as steam within the next second, or whether the next male kitten born to a tortoiseshell female cat will be black or yellow. Some people think that no one will ever be able to make such predictions. But, anyway, if we are dealing with millions of molecules and thousands of cats we can predict the future with very great accuracy. We can say how many molecules will boil away in the next minute and what fraction of kittens will be black.

If we are dealing with a piece of matter of ordinary size—say a penny, which contains millions of millions of atoms—predictions based on statistical theory are so accurate that we cannot weigh or measure finely enough to check them completely.

Now, the calculations concerned in the theory of probability are certainly not reversible. You can't argue back from the kittens to the cat except in very special cases. Modern mathematical physics and biology emphatically support the view that change is real, and not, as Dean Inge thinks, an illusion due to the fact that we travel through time one way rather than the other.

The Dean goes on to say that, according to physicists "the universe is steadily running down like a clock." This theory was put forward about seventy years ago by Clausius. Engels at once attacked it. It is quite plausible, if the sun was created hot, that it will cool down, and by and by the seas will freeze and the earth will become uninhabitable.

Once again, this is a nice theory for people who think that it is foolish and presumptuous to plan too far ahead. Dean Inge, however, says that he is "prejudiced in favour of the old theory of recurrence." So many thousand million years hence all events are to repeat themselves. Another Dean Inge will be born to win another scholarship at another Eton, to wear gaiters and write for another Lord Beaverbrook.

A very consoling theory if you happen to have lived a comfortable life. Not so pleasant if you are dying in a concentration camp or have a cancer which cannot be removed because the hospitals are being kept empty in expectation of air raids. And, like the clock theory of the universe, quite out of touch with modern developments of physics.

Both these theories came naturally to physicists who were constantly concerned with machines, and were accepted by a ruling class which wanted to believe that the laws of economics were unalterable, and that therefore capitalism would be eternal.

But, like all theories which make out either man or the universe to be a machine, they are much too simple. It seems likely that the laws of Nature are actually changing in a manner first suggested by Bartlett, a British expert on probability and a former colleague of my own, and developed by Milne and Dirac, who are probably our leading mathematical physicists to-day.

On Milne's theory, chemical changes, including those in our own bodies, are speeding up relative to physical processes such as the year. If so, however far the temperature may fall, it will not necessarily mean the end of life, though life will doubtless be very different. It may take a century before this theory can be tested, since the changes are very slow, if they happen at all.

But we can hardly expect Dean Inge to take cognisance of such work as this. Such men as he have a very definite function to perform. Their business is to head people away from "dangerous thoughts." By so doing, they may possibly postpone the coming of Socialism for a few years. If so, they will ensure that the breakdown of capitalism will find us unprepared, and that in consequence the transition to Socialism will be as difficult and bloody as possible.

TIME SCALES, AND H. G. WELLS

I HAVE just been reading H. G. Wells's *The Fate of Homo Sapiens*, which he says will be very unpleasant unless we follow his advice fairly quickly. I don't propose to review the book here, but merely to criticise one point. He thinks man may have come to the end of his progress and be heading rapidly for extinction, as the great reptiles became extinct at about the time when the sea spread over what is now south-eastern England and laid down the chalk.

One mistake which I think he has made is to mix up two processes, biological evolution and social change, which have different time scales. Twenty thousand years ago, the inhabitants of Europe used tools of chipped flint and carved bone. They were hunters and had not even learned to polish flints.

But they were essentially modern men as regards their skeletons. And there is no reason to believe that if a baby from the old Stone Age could have been miraculously preserved until to-day, it could not be brought up as a decent member of modern society. Only a few animal species have altered much during this time, except those which have been domesticated.

The Nazi theorists make the same mistake. They think (or say they think) that by purifying the German race they will produce a nation of supermen. As they are busily absorbing Czechs and trying to absorb Poles, this is hardly likely to happen. Actually, however, the idea is unsound theoretically. The human races have taken many thousands of years to develop, and we do not know enough about how they did so to speed the process up.

The evolution of man from lower animals is a very important truth, because it is part of the great truth that everything changes. It helps us to understand that societies must change too. But it is a process on a different scale from social change.

We know of a great many different rates of change in the universe. Some are more or less steady, others periodic. The slowest processes are the movements of the galaxies. Each galaxy is a cloud of stars, and our sun is one star in such a galaxy. We see the main body of our own galaxy as the Milky Way.

These galaxies seem to be moving apart, so that their average distances will be doubled in about 2,000 million years. And our own sun goes round the centre of the Milky Way about once in 250 million years. However, the size of these bodies is so huge that the stars are moving at speeds measured in miles per second.

Our own earth is constantly changing, and every 200 million years or so we have a series of ice ages. We are just at the end of such a series, or perhaps in a warm stage intermediate between two ice ages. The earliest animals whose skeletons are preserved lived about 500 million years ago. So evolution is a very slow process, and it generally takes 1,000,000 years or so for any very marked change to occur.

The earth spins round on its axis once a day, but the axis changes its direction like a top, pointing to the present Pole Star once in 26,000 years. In 13000 B.C. Vega, the brightest star in the Lyre, was the Pole Star, and so it will be again in A.D. 13000. And yet within the time of that half swing man has passed from the hunting stage through animal husbandry and agriculture to industry.

Next comes the time scale of events which take place within a human lifetime, and not too fast to observe directly. These vary from revolutions of the planet Saturn round the sun, once in twenty-nine and a half years, to the heart beat, a little over once a second. But we cannot directly count things happening very much faster than this.

The first class of rapid events—the nearest to our every-day time-scale—are those which take from about $\frac{1}{10}$ to $\frac{1}{10{,}000}$ second, and give rise to musical notes if they occur regularly, like the beats of an insect's wing or the vibrations of a piano wire. A great many of the events in our own body—for example, the passage of impulses along a nerve fibre—are on this scale.

The time scale for chemical molecules is even smaller. When you work you use oxygen to burn sugar, and the exhaust gases come away in your breath. Some of the enzymes, which play much the same part in this process as a sparking plug in a motor cycle, take about a millionth of a second to bring about a chemical change. This is also the time taken by a radio wave of 1,000 kilocycles.

And far below these are the time scales appropriate for light, whose periods are round two thousand million millionths of a second, X-rays, and other kinds of radiation. The important thing to realise is that as one passes along the scale of frequency, things change their quality, and we have to think about them in a different way. We can speak of about nine different time scales, each of whose units is about 10,000 times that of the last.

Beginning from the smallest, they are the X-ray time scale, the light time scale, the time scale for ultra-short radio, that for ordinary radio, that for sound. Then comes the time scale of everyday life, with a minute as unit, the time scale of history, with a year as unit, the time scale of evolution, with a 10,000-year unit, and the time scale of cosmology, with a unit of 100 million years. Probably the progress of science will necessitate still finer and coarser scales.

I know that most people find these large numbers difficult, though the Indian philosophers were using them thousands of years ago. But if we do not bear them in mind, we may make mistakes as ridiculous as trying to swim across the Atlantic or to measure bacteria with a tape measure. And some of these mistakes can affect our political thinking.

THE MILKY WAY

In an earlier article I wrote about the measurement of very large and very small lengths of time, and I dare say a lot of readers thought I was being very dogmatic, like Archbishop Ussher when he calculated from the Bible that the world had been created in 4004 B.C. So I shall try to explain how one of those figures was reached.

The first thing to notice is that all of them have been calculated by several independent methods, which give roughly the same figure. Unless this is done, one may easily fall into serious error. Let us begin with the biggest figure, the rotation of the sun round the centre of the Milky Way once is about 250 million years. The first thing was to get an estimate of its size.

This was done in several steps. First the size of the earth was measured. This took a long time, but is now accurately known. Then observations of the solar system were made at the same time from different points. Every century or so, the planet Venus passes directly between the earth and sun, and can be observed with a telescope. This event looks different from different parts of the earth, as a nearby solid object looks different when you look at it first with your left and then your right eye.

So Captain Cook was sent to observe a transit of Venus from the island of Tahiti in the Pacific Ocean in 1769, and the distance from the earth to the sun determined. On the way back he annexed Australia. If he had been born in 1898 instead of 1728 he would not now be commanding one of His Majesty's ships, as he was the son of a farm labourer and apprenticed to a haberdasher at twelve years old—in fact, he was not a gentleman.

The distance from the earth to the sun was checked in another way. It was known that the eclipses of Jupiter's moons, which can easily be observed with a small telescope, were seen before the calculated time when the earth was nearest to Jupiter, while they were late when it was farthest away. When the speed of light was measured by Fizeau and Foucault in the nineteenth century, the diameter of the earth's orbit could be calculated, and the figures agreed. Since then there have been other checks.

This gave astronomers a base-line 180 million miles long instead of a mere 7,000 or so. And by observing the same group of stars first in January and then in July, we can see the near ones apparently move against the background of the far ones. In this way the distances of hundreds of stars have been measured.

Once again the distances have been checked. A number of what we see as single stars are shown by a telescope to be double. That is to say they consist of a light star going round a heavy one as the earth goes round the sun, or two of much the same weight revolving round their common centre of gravity. This showed that distant stars obeyed the same law of gravitation as the earth.

But if the distance of a pair was known, the speed at right angles to the line of sight could easily be calculated, and the speed in the line of sight with only slightly more difficulty. Now, when a star is moving towards us the distance between successive waves is reduced, and it appears bluer. When it is moving away, it appears redder. So the distance in the line of sight can be measured, and once again agrees with calculation.

We can only measure the distances of the nearer stars in this way. But the stars show a great deal of regularity. When we know their distance, we can calculate how bright they would be if they were so near as the sun. It turns out that the spectrum of a star—that is to say, the colour as analysed by the spectroscope—depends on the absolute brightness.

Again, some stars vary in brightness with a regular period, which may be anything from three hours to three weeks. And here, too, there is a simple relation between the period and the absolute brightness. So we have only to measure the period of such a variable, and its apparent brightness, to calculate how far away it is.

By these two methods, and others, all of which agree pretty well, it has been possible to calculate the size of the Milky Way, and the sizes and distances of the nearer galaxies. They mostly have a spiral structure and appear to be clouds of stars spinning round their centres.

But they do not spin like solid bodies. The stars near the middle complete the circuit in a shorter time than those at the outside. So by measuring the motion of the stars in the neighbourhood of the sun, a rough calculation can be made of how long it will take the sun to go once round the centre. The answer is between 200 and 300 million years.

This is an example of the chains of observation and reasoning by which these enormous figures are reached. But astronomers are not satisfied with them. They are always trying, not merely to make their figures more accurate, but to check them, if only roughly, by independent methods.

There is a political moral here. If we try to think as scientifically as we can about society, we probably become Marxists. That is good, but it is not enough. We have constantly to check our theory to see if it will explain all sorts of phenomena, from the behaviour of Mr. Chamberlain or Herr Hitler to that of your boss or the bus-driver.

Only when we have done this shall we be good enough

Marxists to see an inch in front of our noses in political and economic matters, and to convince our friends that Marxism is correct.

ATOM-SPLITTING

THIS is a sensational article. I am sorry. In these articles I try to keep to facts. But occasionally facts are sensational. A discovery has just been made which may revolutionise human life as completely as the steam engine, and much more quickly. The odds are against its doing so, but not more than ten to one, if so much. So it is worth writing about it.

In the *Daily Worker* of March 30th, 1939, I described the recent work on splitting the nuclei of uranium atoms. A certain number of them explode when neutrons collide with them. Neutrons are among the so-called elementary particles—that is to say, particles which have not yet been broken up, such as electrons, protons, and perhaps a few others. This does not mean that they will never be broken up.

Ordinary atoms hold together when they collide at a speed of about a mile a second, as they do in air. When the temperature is raised and the speed of collisions goes up to ten miles or so a second, they cannot hold together, but electrons—that is to say, elementary particles with a negative charge—are torn off them. That is why a flame conducts electricity.

But at moderate speeds—say, a few thousand miles per second—collisions only break up the atoms temporarily.

They soon pick up their lost electrons. When the speed rises to tens or hundreds of thousands of miles per second, the nuclei, or cores of the atoms, are sometimes broken up.

When a current is passed through the heavy variety of hydrogen at a voltage of half a million or so, the atomic nuclei become formidable projectiles, and if they hit a light metal called lithium they break up its atomic nuclei and let neutrons loose. Neutrons can penetrate the nuclei of many atoms even when moving slowly and cause still further changes.

Generally they only chip a piece off. But when they attack uranium, an element which is unstable, anyway, and produces radium, though very slowly, when left to itself, the uranium nuclei split up. The new fact, first discovered by Joliot and his colleagues in Paris, is that when the uranium nucleus splits, it produces neutrons also. In the experiments so far made, very small pieces of uranium were used.

So most of the neutrons, which can penetrate even metals for some distance, get out. But if the neutrons are liberated in the middle of a sufficiently large lump of uranium, they will cause further nuclei to break up, and the process will spread. The principle involved is quite simple. A single stick burns with difficulty, because most of the heat gets away. But a large pile of sticks will blaze, even if most of them are damp.

Nobody knows how large a lump of uranium is needed before it begins to set itself alight, so to say. But experiments are already under way in two British and one German laboratory to my knowledge, and doubtless in others in America, the Soviet Union and elsewhere.

In the current number[1] of *Nature* Joliot and Halban, a French and a German physicist working together in Paris, published an S.O.S. letter suggesting means for slowing the process down, so as to avoid disaster.

If the experiment succeeds several things may happen. The change may take place slowly, the metal gradually warming up. It may occur fairly quickly, in which case there will be a mild explosion, and the lump will fly apart into vapour before one atom in a million has been affected. Or there may be a really big explosion. For if about one four-hundredth of the mass of the exploding uranium is converted into energy, as seems to be probable, an ounce would produce enough heat to boil about 1,000 tons of water. So 1 oz. of uranium, if it exploded suddenly, would be equivalent to over 100,000 tons of high explosive.

Of course, no one will begin with an ounce. Still, they may do a good deal of damage. Most probably, however, nothing much will happen. It may be, for example, that the majority of uranium atoms are stable, and only one of the several isotopes (as the different sorts of atom of the same element are called) is explosive. If so it will take several years to separate the isotopes.

Nevertheless, the next few months may see the problem solved in principle. If so, power will be available in vast quantities. There will be a colossal economic crisis in capitalist countries. There is plenty of uranium in different parts of the world, notably northern Canada, the Belgian Congo, Czechoslovakia and in several parts of the Soviet Union.

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[1] May 13th, 1939.

So the owners of uranium ores will make vast fortunes and millions of coalminers will be thrown out of work. The Soviet Union will adopt the new energy source on a vast scale, but the rest of the world will have a much tougher job to do so. Fortunately, uranium bombs cannot at once be adapted for war, as the apparatus needed is very heavy and also very delicate, so it cannot at present be dropped from an aeroplane. But doubtless uranium will be used for killing in some way.

An intelligent reader may well ask why, if uranium is so explosive, under certain conditions, explosions do not occur in Nature. The answer is that uranium does not occur in Nature in a pure state. It is generally found combined with oxygen, and neutrons would be stopped by the oxygen atoms to such an extent that an explosion could not possibly spread.

I repeat that this article is highly speculative. I am prepared to bet against immediate "success" in these experiments. Nevertheless, some of the world's ablest physicists are hard at work on the problem. And the time has gone past when the ordinary man and woman can neglect what they are doing.

REVOLUTION IN THE TEXTILE INDUSTRY

WHILE British industry is being switched over to war production, the American textile industry is being revolutionised. Spinning and weaving are very ancient arts, and the first industrial revolution mechanised them, and thus threw millions of hand-weavers and hand-spinners out of work, though in the long run it made clothes cheaper.

But most modern factories use the same raw materials as the weavers of the Stone Age. The main exception is rayon. Selective breeding has, of course, improved the wool yield and quality of sheep, the silk yield of silkworms, and the fibre yield of cotton, flax and other plants. However, there has been no technical revolution in the supply of raw materials.

To-day we are at the beginning of a revolution in the raw material of textiles, which may prove as important for human society as that in spinning and weaving methods. It was made possible by the progress of organic chemistry. At first the chemists confined their attention to small molecules, such as alcohol and acetic acid. When they went on to larger ones, they chose those which crystallise easily, like quinine and sugar, for crystallisation is an easy way of purifying a substance.

Later on they began to study other substances which would not crystallise or would only do so with great difficulty. These included natural products, such as proteins and fibres, and also resinous substances which had been formed in the laboratory and which the older chemists had thrown away. Some of these latter—for example, bakelite—proved to be valuable plastics, and have found a place in industry.

The chemists who investigated fibres did not get very far until they used X-rays. Now X-rays have two distinct uses. They go through things which are opaque to ordinary light, and this property is used by surgeons to investigate broken bones or by metallurgists to find flaws in castings.

But they have another property. If lines are ruled very finely on glass or metal, say 10,000 to 1 inch, they give it an iridescent appearance—that is to say, light of one wavelength is reflected at one angle, light of another wavelength at another. The same principle applies to X-rays, but they have very small wavelengths, so they are suited for detecting regularities occurring, not 10,000, but 10,000,000 times in 1 inch.

For example, they can detect the regularities in a crystal which is built up of millions of layers of molecules piled in a regular manner. And this analysis showed that natural fibres were built up from fairly simple chemical molecules united together to make giant molecules which might be built up of thousands of smaller ones.

Now, the chemical units in an animal or vegetable fibre are the ordinary molecules found in the cell, stuck together in a chain. But they are not the best possible ones for the purpose. For example, a cotton fibre consists of thousands of small fibres side by side, each made of hundreds of sugar molecules. But the sugar molecules are round. Just as one can make a better chain from oblong than from round links, one can make a better fibre from long than from round molecules.

This simple principle is at the basis of many of the new textile materials. For example, nylon, a fibre produced by the du Pont de Nemours Company in the U.S.A., is built up of long molecules stuck together in the same way as the much shorter molecules in natural silk. The chemicals which unite to make the fibre are not made by a caterpillar, but by men using coal as their original raw material.

In fact, nylon is silk without a lot of chemical extras which do not add to the strength of the natural material. It is claimed that it is tougher and more elastic than silk, and it is certainly equally lustrous. Further, it is going to be cheaper. As silk is one of Japan's chief exports, this is one reason why the Japanese will find it difficult to keep up their war in China much longer.

Another big American firm is putting out a similar material called "vinyon," which is claimed to be more waterproof, and also more proof against acids and alkalies, than nylon. These are only the first of a series of fibres which are probably going to oust many of our present textiles.

What effect will this have on the ordinary man and woman? It may mean that Lancashire will be even worse off after this war than after the last, for new fibres require new weaving processes. It will also mean that some colonial products, such as cotton, are likely to become less important.

Besides this, it will introduce new health risks in factories. In the manufacture of such substances solvents are often used whose vapours are dangerous.[1] The workers generally have to wait till a few of them have been killed and many injured before anything is done to protect the rest. The T.U.C. ought to have a department studying health risks in new industrial processes.

Still other American firms, such as the Owens-Illinois Glass Company, are making fabrics from glass fibre. These are not only beautiful, but absolutely fireproof and acid-proof. They are still too harsh to wear, but are being used for fireproof curtains and furniture.

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[1] See p. 229.

Excellent. But what about the dust? Much of the dust in our homes consists of wool and cotton fibres. What is going to happen to our lungs if we start breathing glass fibres? The new industrial revolution will raise as big economic and health problems as the old. Unless the workers are ready to meet these problems, they will suffer as their ancestors did in the past.

PUBLIC HEALTH

CAUSES OF DISEASE

I AM constantly being asked questions about the cause of such and such a disease. These questions are almost always of the unanswerable kind, like: "Have you left off beating your wife?" No event ever has only one cause. A house was burnt down. Here are some of the causes: A man was smoking a cigarette. He was careless, and threw the stub down without putting it out. There was a pile of waste paper in the corner. The floor was made of wood. There was no fire extinguisher in the house. There was about 21 per cent. of oxygen in the air.

All of these were causes. If any had not been the case, the house would still be there. None of them was *the* cause. Some people would say that the best way to stop such fires was to discourage smoking; others to teach greater care by smokers. Others, again, would concentrate on building houses with cement floors or forcing landlords to provide fire extinguishers. A lunatic might say: "Why not reduce the amount of oxygen in the air, so that wood won't burn?"

The position is just the same with the prevention of disease. Every disease has a great many causes. The only scientific thing to do is to investigate as many of them as possible, and find out which are the easiest to tackle. Let us take the case of smallpox. Nobody doubts that it is infectious, and it is extremely probable that the germ is a virus too small to be seen with a microscope, but not too small for its size to be found by other means.

There is less certainty how it is transmitted. Probably it can be transmitted by fragments of skin in old clothes, by drops of water in the breath, and in several other ways. So overcrowding and dirt are conditions for its spreading, and in most epidemics these are among the causes. Besides these general hygienic measures, people who have been near a case can be isolated, and vaccination can be practised.

Now, vaccination is not perfectly safe. Occasionally either the vaccinia virus or something else found along with it in the vaccine causes fatal brain inflammation in a child. Nor is it perfectly effective, for it does not give permanent immunity against smallpox, except perhaps to a few people.

And the statistical evidence as to its immunising value is not very straightforward. For one thing, several different diseases are classed as smallpox, including a very dangerous one and another which causes a nasty outbreak of spots, but only kills about one in fifty. As I see it, a great deal of the propaganda both for and against vaccination is intellectually dishonest.

Nevertheless, I would have any baby of mine vaccinated, and would be re-vaccinated myself if I were going to a country where smallpox is common, because my own study of the statistics convinces me that vaccination greatly improves one's chances in an epidemic.

In spite of this, I would agree with the anti-vaccinationists that cleanliness and decent housing can do more than vaccination to reduce deaths from smallpox. What is more, the disease can never be wiped out until the standard of life in India, China and other countries where smallpox is always present has been raised to a much higher level.

Epidemic disease is a world problem, and the great masses of half-starving workers abroad not only help to depress wages and cause unemployment here, as when Indian and Japanese workers lower the standard of living in Lancashire cotton mills. They serve as a hotbed of disease from which epidemics can spread to the rest of the human race.

Let us take another example, that of the venereal diseases, which always increase when family life is broken up as the result of war. There is no doubt that they are caused by the transmission of quite definite microbes from one person to another by close contact. But what is the cause of their spread in war, and how should it be prevented?

Some people say that soldiers should be compelled to use antiseptics to prevent their spread, and that this is enough. The Association for Moral and Social Hygiene have protested to the Government against this practice. The International Woman Suffrage Alliance agree, but add that soldiers should be given opportunities for recreation, as a check on promiscuity.

Now, the problem of the sexual life of soldiers became acute in the Soviet Union, and was tackled in a truly Bolshevik way. Young men have strong sexual desires, but in a healthy society almost all prefer marriage to promiscuity if they can afford it. In the Soviet Union a wife generally works, and is paid during the months before and after birth. So marriage does not lower a man's or woman's standard of life, as in Britain. And who can blame a soldier for refusing to marry when he reads of the allowances which his wife and children may expect?

Soldiers in the Red Army are encouraged to marry, and proper provision is made for their wives to live with them whenever possible. Hence, though much still remains to be done, there is less sexual promiscuity in the Red Army to-day than in any other. The root cause of the spread of venereal disease, if it occurs during the present war, will not be the wickedness of men or women, but the economic system which discourages early marriage.

Many people to-day write of the menace of the Red Army, the largest army in the world. It is the largest army because the Soviet Union is the only state with a low death-rate and a high birth-rate. No healthy married couple in the Soviet Union need limit their family for fear of unemployment or malnutrition of their children.

So long as the Soviet Union is unique in this respect, it is likely to go on having the world's largest army. And a good thing, too.

VENTILATION IN WARTIME

DURING the last war there were a great many outbreaks of epidemic disease. Some were caused by contamination of food or water. These were the easiest to deal with. Others were spread by lice. The worst of these were the great epidemics of typhus fever which began in Serbia in the first winter of the war, continued in the Russian Army on the Eastern Front, and spread through the Russian population during the civil war and the wars of intervention.

Body lice can be exterminated by washing the clothes and the body, and where people have a chance of ordinary cleanliness there is no danger of typhus. But the worst epidemics of all were spread by the breath. First came outbreaks of cerebro-spinal meningitis, generally called "spotted fever," in the camps and to a less extent among civilians. At the end came the great influenza plague, which killed more people than the war.

We don't know how an epidemic of this kind starts. But we know enough to say that the germ theory, though true, is not the whole truth. Quite healthy people may carry germs which under certain circumstances may cause a disease. They occasionally pass them on to someone else without doing any harm. But if the germs are passed on rapidly enough they become virulent, and cause a serious illness.

All kinds of processes suddenly change their character when they are speeded up. When glowing coals heat to a certain point they suddenly burst into flame. Smoothly flowing water begins to ripple and eddy, a demonstration turns into a revolution, and so on. We don't know just what happens in the case of an infection. We must remember that bacteria may divide twice in an hour. This means that they have as many generations in a week as a race of men in 100,000 years, and can actually change their character by evolution.

However the change takes place, we shouldn't let it happen. And it is liable to happen if people are overcrowded. Eighty years ago Florence Nightingale managed to persuade the War Office that soldiers' beds in barracks must be at least 3 feet apart. As soon as this distance is cut down, diphtheria, spotted fever and other diseases arise.

They are all throat infections, which arise when men sleep with their mouths open, and thus do not use their noses to filter off the bacteria spread by their room-mates. The infection is naturally worse when the windows are shut, owing to black-out regulations. It is up to every democrat to see that lives are not thrown away, as they were in the last war, by overcrowding in barracks and huts. This can be prevented if soldiers, sailors and airmen report any cases of overcrowding to their M.Ps.

Other infections, such as influenza, are spread in the daytime. And here the danger is more widespread. As a result of black-out precautions, many windows have been boarded up "for the duration," and the ventilation in factories and offices has been cut down, while staffs have often been increased. It is up to the unions to see that standards of ventilation are enforced. The same is true of pubs. Even if you get wet, you are far less likely to get ill selling the *Daily Worker* in the streets after dark than sitting in a stuffy bar or even a cafe!

Besides these dangers, which apply to millions of people, there are other dangers in the fighting services. The crews of submarines are exposed to special dangers. Not only may they be suffocated if they stay too long on the bottom, but they are liable to be poisoned by small quantities of three gases. Carbon monoxide from a leak in the exhaust may poison them when the engines are running on the surface. Chlorine may be formed if sea water gets into the storage batteries.

And if the sulphuric acid in the batteries contains a trace of arsenic, this may form hydrogen arsenide. When air containing even 4 parts in a million of this gas is breathed for long enough, men get jaundice, neuralgia and other symptoms. The batteries are now sealed up, but leaks are always possible, and constant vigilance is needed.

A number of soldiers on both sides during the last war were killed by carbon monoxide poisoning. The gases which come out of the muzzle of a rifle or machine gun contain a certain amount of carbon monoxide. There is not enough to be dangerous in the open. But if a machine gun is fired from a concrete pillbox or a tank, its crew may be poisoned.

This danger is, of course, understood, but precautions which are taken in peacetime are inevitably relaxed in war, particularly if there is any danger of a gas attack. During this century, the health of the fighting services has been vastly improved. In a war there is always a tendency to neglect hygienic measures. The results of doing so are fatal. By working for good health conditions in the forces, you are at the same time saving the lives of your fellows and helping to smash Hitler and all that he stands for.

RATIONING

THE word "rationing" is used in Britain to-day for two quite distinct purposes. In the first place, the armed forces get a certain amount of free food per day. During the last war these rations were generally good, or at any rate better than our food in civilian life. Not always, though. The worst I got were in Mesopotamia, where we had very hard biscuits made in Delhi, on which I broke at least one tooth. Fortunately, about one tin in three was full of weevils, which softened the biscuits for us, and did not taste at all bad, if one was sufficiently hungry.

The troops were not so well fed until recently. Up till about 1908 the soldier could not live on his rations. He had to buy extra food at canteens. Then an experiment was made. A number of Regular soldiers were asked to volunteer for it. They promised not to buy any food beyond their rations, and had to march about twenty miles with full equipment every day for a month.

It was at this time that the first hunger marches of unemployed were being organised. The company of volunteers was nicknamed the "hunger marchers." All of them lost a good deal of weight. But the only casualty was a man who got so hungry that he ate woody nightshade berries. As they were not deadly nightshade, he did not die of them.

The soldiers' ration was then increased, so that they got enough to eat, even when marching. In consequence, the Army got more food than it needed for trench warfare. One of the chief extras was jam, and the "plum and apple" with which we got so fed up was introduced as a result of this march.

The experiment showed that the soldiers' ration had not a high enough fuel value when they were working hard, and jam was used as a supplement because, apart from water, it consists largely of sugar, which is a good fuel for work, but is not much use for building up new tissues or repairing old ones.

For this purpose, we need proteins, such as are found in meat, fish, cheese, eggs and so on, and to a less extent in bread, beans and many other foods. They are specially needed by recruits who have been unemployed or engaged in light work, and have to develop their muscles when they join the Army.

Besides this, the soldier needs small amounts of vitamins, which he gets in butter, fresh fruit and vegetables, and in various other foods. A monotonous diet is apt to be short in one or other of the vitamins, and, if there is anything wrong with the Army ration, it is likely to be a vitamin shortage. However, most soldiers probably get better food than they did as civilians.

Besides this, we are told[1] that some foods are going to be rationed for civilians. A foreigner who looked up the word in a dictionary might think that this meant that the Government intended to see that every civilian got a free ration of food, which, like the soldier's, was more or less scientifically planned on the lines of the Communist slogan: "To each according to his needs."

This is certainly not going to happen. Some foodstuffs, such as meat and butter, will be rationed, so that nobody can buy more than a certain amount, unless, as sometimes happened in 1918, he buys rationed foodstuffs from a poorer neighbour. But there will be plenty of unrationed foods, so that those who can afford them will not go short. And there will be no such increase of wages, allowances

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[1] Autumn, 1939.

and pensions as to make sure that everyone will be able to buy enough food.

In fact, rationing means something very different for soldiers and civilians. Nevertheless, it is worth thinking what rationing would mean in a Communist society. Probably something like this. Everyone would have a right to as much free food as they wanted, either at public canteens or brought home in a container from the nearest public kitchen.

The ration would be planned on scientific lines and would be sufficient to meet all needs. For children it would be of a high quality. For adults it would be plain but wholesome. If anyone wanted something extra—say, chicken instead of ham or beer instead of tea—he would have to pay for it. That is to say he could choose whether to spend his wages on luxury foods and drinks or on books, travel or amusement.

A community which planned its life would see that every member of it got food, housing, clothes and so on of a high enough standard to keep him or her in health, as well as education and rest. But, apart from this, they would have as wide a choice as possible in spending.

There are some who say that it would be easier to carry out the Socialist principle, "To each according to his work," than the Communist principle, "To each according to his needs." This is certainly not so in many cases. It is hard to say whether a day's labour of a stevedore or a clerk has the greater value. It is certain that the stevedore needs more food. On the other hand, the clerk needs a garden to dig, a swimming pool or a tennis court to keep fit, while the stevedore does not need any more exercise than he gets.

The value of the clerk's labour may diminish because an adding machine will do his work more cheaply—that is to say, with less total expenditure of human labour. But needs are largely a matter of human physiology, which is not changed by technical inventions. So a biologist inevitably thinks in terms of human needs and looks forward to a society organised on this basis.

BLOOD-DONORS AND VENEREAL DISEASE

Last week[1] I went round to a hospital to register as a blood-donor. They took a few drops of blood from my ear, in order to determine the group to which I belong, and made me sign a form to say that I had not had malaria or any other serious disease. This is a lie, anyway. I have had several serious diseases, including measles, which kills more people in Britain than plague, cholera, small-pox, typhus and half a dozen serious diseases put together.

But I understood what the question meant. They wanted to know if I had had syphilis, and were too polite to ask me. I was frankly horrified. Once again the lessons of the Spanish War have not been learnt. When I was in Madrid at Christmas, 1936, a Canadian medical unit was arranging for blood transfusions. In the first rush of work they had unavoidably accepted any healthy-looking people who volunteered. They were just beginning to discover

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[1] August, 1939.

that some of their bloods contained the germ of malaria, others that of syphilis.

Doubtless a few wounded soldiers had been affected with one or other of these diseases. This could not be helped. If the transfusion unit had refused to accept blood until proper tests had been made, a lot of men would have died. It was better for them to run the risk of infection with two curable diseases. I have not mentioned a number of much rarer ones which could, in theory at least, be transmitted in the same way.

The Spaniards were in a desperate hurry. Only later on did they find time to test their blood-donors. We do not seem to be in any sort of a hurry in this country. In fact, one of Sir John Anderson's slogans about A.R.P. is: "I refuse to be hurried." There is no excuse whatever for our failure to make the necessary tests.

Certainly they are harder to make than the very simple tests needed to assign a person to the correct blood group. And they cost more. But there are a number of people fully able to do them, and out of work, including British laboratory workers and refugee doctors from Europe who are not allowed to practise medicine here.

What are the tests in question? The germs which cause malaria live in the blood and it is easy to see them with a microscope. The germ which causes syphilis is hard to see with a microscope and is pretty rare in the blood, though there may be quite enough to infect someone else. So a test of a different kind is used. It is not a microscopical test, like the test for malaria, nor a chemical test, like the tests for kidney disease, diabetes and rickets, but an immunological test.

The simplest of these tests, and one of the most effective, is the Kahn test. In this test the blood is allowed to clot and the clear fluid drained off. This clear fluid, called the "serum," is mixed with a milky fluid made by suspending an extract of ox heart in a special salt solution, and shaken up. If there is a precipitate, or even if the particles in the milky fluid stick together to a moderate degree, the blood-donor is probably infected with syphilis.

Of course, the amounts of everything used must be carefully measured, the temperature and even the rate of shaking must be just right, the glassware must be scrupulously clean, and so on. Other tests are still more complicated. But such tests are part of the routine of every hospital, and they were the routine for blood-donors in Spain.

Some people will say that the danger of infection is remote. The answer is that in England and Wales even in 1937 over 19,000 cases of this disease were dealt with for the first time at treatment centres. Most of those people had had syphilis for more than a year before they applied for treatment. And many others, especially women, get no treatment at all, because they do not know that they are infected.

At the present time there is a great campaign to wipe out this disease in the United States. The need for treatment is mentioned in the Press, and an attempt is made to stamp out the poisonous lie that this disease is a divine punishment for sexual immorality. It can be transmitted from one person to another in a number of ways, and blood transfusion is one of them. American public opinion would never stand for the transfusion of untested blood.

A good many people who have had this disease in a mild form and suffered from nothing worse than a sore throat and a few spots on the skin have no idea what is wrong with them. On the contrary, numerous sellers of "patent medicines" describe the symptoms of this disease and put them down to "bad blood," which they promise to purify. Such people may become extremely ill later on, but meanwhile they could honestly enrol as blood-donors and say that they had not been seriously ill.

I do not want to start a panic. If I am wounded in an air raid and need a blood transfusion, I will take my chance of getting malaria, syphilis or several other chronic diseases. They can all be cured, and death can't. But I object to taking unnecessary risks.

When Parliament meets again, I hope that some Members will take the matter up. But until then nothing will probably be done. It is worth remembering that a long parliamentary holiday not only makes things easier for the friends of Fascism, but for the friends of every kind of negligence. I wish I had volunteered as a blood-donor a week earlier. I would have got Willie Gallacher to ask a question about this particular menace to our lives.

WHAT BLOCKADE MEANS

AT the present moment[1] the British and French are trying to blockade Germany, and the Germans to blockade Britain. Incidentally, a number of neutral countries are undergoing a partial blockade. For the Germans are

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[1] December, 1939.

sinking their ships, and the British will doubtless try to stop them from importing food for re-export to Germany.

This blockade does not merely extend to metals and other materials which could be used for munitions—including fats, which are a source of glycerine, one of the raw materials for cordite and similar explosives. It extends to foods of all sorts.

At present neither blockade is very effective. The U-boats are less destructive than in 1914–18, because the British Navy then found out how to deal with them. And the Germans will probably be able to buy wheat from the Soviet Union. It is more doubtful whether they will get much meat and dairy produce.

But, later on, either side may be more successful, if only because growing economic difficulties may make the belligerent governments use their shipping and foreign currency to buy munitions rather than food. This has been the German policy for some time. In a recent speech, Mr. Lennox Boyd has foreshadowed a policy of guns before butter for Britain also.

Let us see what a successful blockade would mean. In 1914–18 there was no serious food shortage in Britain. It was terrible, not only in Germany, but in neutral countries. In Britain the average weekly consumption of flour for bread, biscuits and so on rose from 6 lb. in 1913 to 6½ lb. in 1918. In Germany it fell from 6½ to 5; in Holland from 7¼ to 3. Meat consumption fell slightly in Britain, catastrophically in Germany and Holland.

Now, foods are needed for several purposes. First of all, they are needed as a source of energy for heat and work. The energy value of a diet is measured in kilocalories. In

Germany the energy value of the food fell from about 4,000 to 2,000 kilocalories. A Viennese professor stated that at least 100,000 Austrians out of 7,000,000 died of starvation.

The survivors could not work. The output of workers in Berlin had fallen to half by the end of the war. And they were spiritless and apathetic. To a physiologist, one of the most amazing things about the Russian Revolution is that Kolchak, Denikin and Yudenitch were defeated by hungry men and women.

For body-building, proteins are needed. These are found in large amounts in meat, fish, milk, cheese and eggs; to a less extent in bread, beans and some other foods. A lack of them slows down the growth of children. The average weight of Viennese babies at one year old was 35 per cent. below normal in 1918.

In adults protein shortage leads to hunger dropsy. The blood contains proteins which hold its water back, as gelatin does in a jelly. If they fall below normal, water leaks out of the blood. The belly, and sometimes the legs and face, become puffy. This happens in kidney disease if the blood proteins are lost in the urine. It also happens in famine. In 1917 a thousand Czech civilians died from this cause alone. Some cases occurred in English workhouses and mental hospitals.

Besides this, there are diseases due to a shortage of one of the vitamins. About half the elementary school-children in England are already so short of vitamin A that they take longer than well-fed children to adapt their eyes to see properly in darkness. This is because they do not get enough butter, milk or high-grade margarine. Things are almost certainly worse in Germany. A greater deficiency leads to real night-blindness. The victims can see no better in a black-out after half an hour than on going out into the street. At the same time, they get skin eruptions and soreness of the eyes, which may lead to blindness.

Scurvy, which is due to lack of vitamin C, found in fresh fruit, vegetables and meat, occurred on a large scale in Europe. The symptoms include bleeding from the gums, pain and easy bruising of the limbs, uncontrollable bleeding and so on. In babies there is severe pain in the joints. There were small outbreaks in Glasgow, Manchester and Newcastle in 1917, due to a shortage of potatoes.

A shortage of vitamin D, also found in butter and good margarine, leads to rickets in children and softening of the bones in adults, particularly pregnant and nursing mothers. The leg bones may bend, and the pelvis be so deformed as to lead to death in childbirth.

If the Franco-British blockade of Germany succeeds, it is likely that the civilians who will suffer most will be those of Czechoslovakia and Poland and, of course, the Jews. In 1914–18 the Polish children suffered terribly. Yet blockade is regarded as more humane than the bombing of civilians.

There is a reason for this. Professor Starling reported that even in 1919 about a third of the population of Berlin was reasonably well fed. Bombs kill rich and poor alike, but starvation does not. Rationing is applied to the commoner and cheaper foods. The rich can get bootlegged food, as in Germany, or expensive foods which have not been rationed, as in England in 1918. The country districts are generally better off than the towns, and the rich can move out into the country. For this reason, blockade, unlike bombs and gas, is no serious menace to the ruling class, unless, indeed, it causes revolution.

Such are the facts about the method by which, at the present time, both belligerents apparently hope to win the war. I have seen the effects of blockade on the children of Spain, and regard it as one of the most inhuman of all war measures. It means, in practice, war on the weak. I can only hope that the British Navy will deal with the German submarines and mines, and that the Soviet Union will be able to feed the peoples of Germany, Austria, Poland and Czechoslovakia.

DOES YOUR GAS-MASK LEAK?

In September, 1938, all adults were issued with respirators, and during last year protective helmets were issued to a great many babies. It is generally believed that we are pretty safe against a big gas attack. Nevertheless I think that if air war develops in the spring,[1] a large-scale air raid with gas has more chance of success than seems likely at first sight. Here are my reasons.

In the first place, a great many people have ceased to carry their respirators about with them. This is particularly rash in calm weather, when a gas attack would be most dangerous. Others do not know how to use them. But, even more serious, a very large fraction of the gas-masks have deteriorated. A friend and I recently inspected

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[1] 1940.

twelve civilian respirators. Four of these had small holes in the rubber. One of the respirators belongs to a bedridden woman who had only once taken it out of its case, and had certainly not damaged it in any way.

In many cases the rubber of the respirator has been seriously rubbed along the edge of the filter. This is specially so where the masks have been taken out of their cardboard cases and carried in containers, some of which are totally unsuitable. Besides this, if you hold your mask carefully up to the light and stretch the rubber, you will often find a small pinhole.

You can mend this with rubber solution, but it is better to get a new mask, as other holes may well develop. It is not always easy to get a new one. I tried to do so two months ago, and found that there was not a large-sized respirator to spare in the whole of St. Pancras! The holes are seldom large, but enough gas might easily get in through them to cause the wearers to cough so badly as to make them remove the mask and die in consequence.

It is high time that the wardens were mobilised for a thorough inspection of gas masks. But, as Sir John Anderson is unlikely to read this article or to take any action if he does, I earnestly hope that readers of the *Daily Worker*, who have always taken A.R.P. seriously, will look at their own masks and those of their families, and raise the matter with local authorities.

Are you safe if your respirator is in good condition? Not completely safe. It gives your skin no protection against blistering gases, such as mustard gas. This is particularly serious, because very few shelters have any proper protection against gas. I have yet to see curtains rolled up ready to let down over the entrances to trench shelters or Anderson shelters, though I am told they exist in some places.

And when people learned that a room could not be made really gas-proof by plugging holes, they forgot that it can be made at least partly so by simply shutting the doors and windows and blocking the chimney. These simple measures will do a certain amount to protect you, and may make the difference between life and death.

Rumours are circulating that new gases will be used, against which the respirators are useless. I do not believe them. Nevertheless, the Nazis may try well-known gases which were not used in the last War. One possibility is arsine, the simplest compound of arsenic and hydrogen. So far from being a "new" gas, it has been known for about a century, and its poisonous action was described in 1865.

It is not so poisonous as phosgene—that is to say, the amount which must be present in air in order that ten minutes' breathing of it may be fatal is greater. But it is more treacherous, because it has no irritant effect and, when pure, little smell. It cannot be compressed into a liquid, like chlorine or phosgene. But it is generated by the action of water on aluminium arsenide or calcium arsenide as acetylene is made from calcium carbide. These substances could be sprinkled from aeroplanes or shells in the form of powder.

The technique of scattering powders from planes has been developed in the last twenty years for the purpose of dusting crops with insecticides. But it may be applied to killing men, not insects. These solid compounds give off arsine quickly if there is a shower, more slowly when acted on by the moisture of the air.

The symptoms are fairly well known, because it is a frequent impurity in zinc and other metals and in sulphuric acid. If acid acts on a metal, hydrogen is generally given off, and if the metal or acid contains arsenic, some of it combines with the hydrogen. So a lot of workers have been killed by arsine and many more made ill. During the 1914–18 war, both British and German sailors were poisoned by arsine from storage batteries which had been made with cheap metals or acid containing arsenic.

For the first three hours after breathing this gas, there are no symptoms but slight headache and weakness. Then it begins to act on the blood, breaking up the corpuscles, so that the hæmoglobin, the red pigment contained in them, gets loose and there is violent headache and vomiting. After about eight hours the urine becomes red, and jaundice develops after a day or so.

Death may occur on the second day or later, and if the victim survives he may be ill for months, and neuralgia and other nervous symptoms may last for a long time. Small concentrations of the gas breathed for a long time cause a variety of symptoms, including pain, weakness, and loss of the hair and nails.

The ordinary gas mask gives some protection, but not as much as against most poisonous gases. A special filter can, however, give full protection. For this reason it is most important that, if powder is dropped from aeroplanes, people should keep indoors in moderately gas-proof rooms, and shelters should be made proof against gas.

I do not know if the use of arsine-generating powders is likely, but it is at least a possibility, and wardens should certainly know how to deal with them. The other most likely novelties in gas war are smokes specially invented for war purposes.

Civilian respirators have considerable, though not complete, stopping power for those used in the last war, which have relatively large particles. But tobacco smoke, with finer particles, can get through. And a poisonous or irritating smoke as fine-grained as tobacco smoke might be very effective.

However, the most urgent tasks before the A.R.P. authorities are undoubtedly the inspection of existing respirators, and their repair or the issue of new ones where needed, and the gas-proofing of shelters. If these are not taken in hand, I, for one, shall regard the official anti-gas measures as little more than eye-wash.

NOTE.—Within a week of the publication of this article five similar ones appeared in other newspapers. As a result of this, rather half-hearted official steps were taken to replace faulty respirators. Since then the civilian respirators have been fitted with a new anti-smoke filter, and many public shelters, but no communal shelters, have been fitted with gas-proof or partly gas-proof curtains. No steps have been taken to protect civilians against arsine.

NEWS FROM THE VITAMIN FRONT

SINCE I wrote in the *Daily Worker* on vitamins about eighteen months ago,[1] there have been several developments in this field. One fairly important vitamin has been obtained in a pure state and its composition worked out.

A Danish biochemist called Dam was investigating diseases of young chickens, which, of course, are often brought up on very artificial diets. On one particular group of diets, the chickens suffered from bleeding in various organs and might bleed to death from a small scratch. The blood was very slow in clotting.

He found that this tendency could be cured by extracts of alfalfa, a plant related to clover. Later vitamin K, as the substance in alfalfa was called, was found in a number of other plants, and also in fish meal and other foods. In fact, there is no reason why chickens should die of this condition in future.

But it might have been of no use to human beings. A vitamin is a chemical substance which an animal needs, but cannot make for itself. Thus men and guinea-pigs cannot make vitamin C, or ascorbic acid, so they get scurvy on a diet which does not contain it. But rats and many other animals can make this vitamin, probably from sugar. So they do not get scurvy on diets which give it to men or guinea-pigs.

And there was no evidence that any human beings were suffering from a shortage of vitamin K. Now vitamin K is difficult to make. But a closely related substance can readily be made, and keeps chickens healthy. This is being used on

[1] Articles reprinted in *Science and Everyday Life.*

human beings whose blood does not clot quickly enough.

Doctors are testing it in many countries. In Britain the main work is concentrated in the Royal Infirmary at Edinburgh. Dr. Macfie had some success in cases of jaundice, where the poor clotting power of the blood renders operations very dangerous.

But the most striking effects were found in newborn babies. Drs. Macpherson, MacCallum and Haultain found that bleeding inside the skull was responsible for more than a third of 300 stillbirths and deaths in the first four days of life. Besides those who die, others are paralysed or feeble-minded.

Naturally enough, a baby's head is greatly strained during birth, as the skull is still soft, and small hæmorrhages are bound to occur occasionally. If the blood clots quickly, little harm will be done. But the clotting power is generally low at birth and falls for three days afterwards.

It can be made normal, the Edinburgh doctors found, by giving synthetic substitute for vitamin K by the mouth to the new-born baby, or, better, to the mother between twelve and four hours before the baby's birth. They also found that even when birth had been difficult the babies so treated rarely showed any signs of brain injury.

Of course, the number of babies treated is too small to arrive at certainty, but it looks as if vitamin K might reduce deaths of babies at and soon after birth by about a quarter. But, owing to the war, this possibility will be first tested in the U.S.A. and the U.S.S.R., and a lot of British babies will die needlessly.[1]

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[1] A reader states that large-scale tests are being made in Britain. I hope he is right and I am wrong.

Another important application of vitamins is to miners' nystagmus. This is a disease in which the eyes are permanently moving and vision is impaired. If you want to see what nystagmus looks like, get a friend to turn round very quickly several times, and then watch his eyes.

Miners' nystagmus is certainly due to bad lighting, but most coal-miners, even in poorly lit mines, do not get it, so there must be another cause, or perhaps several. Dr. Kellett of Newcastle-on-Tyne thinks the cause is a shortage of vitamin A. In an earlier article,[1] I told how this vitamin is needed for seeing in the dark, and most children and many adults in Britain are short of it.

So Dr. Kellett examined the diets, during the spring of last year, of forty Durham miners who had never had nystagmus. Their average consumption of butter was 13 oz. per week, and one man ate 24 oz. This is a huge quantity, for even people with over £1,000 per year only eat about 12 oz. per week, and those with incomes under £125 per year average only 4½ oz. Dr. Kellett's miners also ate an egg a day on the average, and large amounts of liver, both of which are good sources of vitamin A.

To-day these miners are restricted to 6 oz. of butter or margarine a week, which may be enough for the average man or woman who does not have to work in darkness. But it is very doubtful indeed whether it is enough either for miners or for drivers of vehicles at night.

Dr. Kellett will perhaps be able to watch the effects of rationing on these men, and see how many develop eye trouble during the war. Even if they do not get nystagmus,

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[1] Reprinted in *Science and Everyday Life.*

their vision in the dark may be affected so as to render them more liable to accidents.

But I, for one, should prefer not to take the risk, and I believe that a special ration of fish-liver oil or margarine of high vitamin A content should be provided, not only for miners and lorry drivers, but for men and women in the forces who have to work in the dark.

In the War of 1914–18 the Germans suffered much more than the British from vitamin deficiencies. According to *The Times*, the German authorities have reacted to the increased night-blindness shown up by their black-out, and "for the moment the demand for more vitamin A has been met by the chemical industry, which has produced an artificial vitamin, possessing, it is claimed, prime value in warding off and curing night-blindness."

The claim that the artificial vitamin is any better than the natural one for this purpose is, I expect, as unreliable as some other German claims. But at least they are tackling the problem. Unless we do so, the British may be worse off than the Germans in the present war.

MY FATHER

ALMOST everyone in Britain was horrified at the story of how the men in the *Thetis* slowly died of suffocation a few feet from safety. And many admired the courage of the four International Brigaders who, though they did not die, at least know how the dying men in the *Thetis* felt. Still more would do so if the *Evening News*, *The Times*, the *Daily Telegraph*, the *Daily Mail* and (in one news bulletin at least) the B.B.C. had not left out the part of my evidence which stated that these men had fought in Spain.

But I believe that in tens of thousands of homes men were saying, and saying quite rightly, "This is what we may have to put up with any day; and if we suffocate there won't be all this song and dance about it." The men who, I expect, said this are miners. A miner may be crushed by a fall of roof, or, if the roof falls between him and safety, he may be suffocated or die of thirst. In an explosion he may be overcome by gas or burnt so that his skin comes off like a glove.

Finally, if there is an accident, it is taken for granted that a miner will risk his life for his comrades. A miner who did not do so would be a freak, like a five-legged calf or a tortoiseshell tom-cat. There is the same high standard of courage among mining engineers and inspectors.

As a result of the *Thetis* disaster, some additional safety devices are to be introduced for submarines. If the public were not so accustomed to colliery explosions, the same would have taken place long ago in coal-mines. In the rest of this article I am going to tell the story of my late father, J. S. Haldane, and of the measures which he recommended for coal-miners forty-three years ago.

His first scientific work consisted of analyses of air in the slums of Dundee in 1885 and 1886. "The one-roomed houses," he wrote, "were mostly those of the very poor. Sometimes as many as six, or even eight, persons occupied the one bed. In other cases there was no bed at all." The average space per person in these one-roomed houses was

212 cubic feet, the same as the volume of the chamber in which I was making experiments in connection with the *Thetis* disaster. The smallest space was just under half this, or much less than the space per man in the *Thetis*, even with twice her normal crew and two compartments flooded.

In 1892 he determined to investigate the causes of the high death-rate in overcrowded dwellings. He shut himself up in an airtight chamber until he felt ill, while the air in the chamber was analysed from time to time. When he came out he vomited. The experiments which I described in the *Thetis* case were merely extensions of this one. He was able to stay much longer, with no bad effects, when a mixture of soda and lime was spread out on a tray to absorb the carbon dioxide produced by his breathing.

These experiments convinced him that the high death-rate in overcrowded houses was not due to chemical causes, but to bacteria. For most floors and walls, especially in slums, are so leaky that the carbon dioxide never gets very high or the oxygen very low. My father was not a bacteriologist, so he looked for places where men were being killed, not by bacteria, but by chemical impurities in the air.

He soon found them. In 1894 he went down Podmore Colliery in Staffordshire and Lilleshall in Shropshire, analysing samples of the gas which accumulated in the old workings, and also breathing them until they made him feel silly. This gas, however, is not so poisonous as the "afterdamp" found after an explosion, and containing carbon monoxide.

In the same year he tried the effects of carbon monoxide first on mice and then on himself. These experiments were rather embarrassing, since mild carbon monoxide poisoning is very like mild alcohol poisoning! One talks too much, and one's legs give way if one comes out into cold air. So when my mother was seen steering my father home from the laboratory, some neighbours thought he was drunk.

In 1896 there were explosions at Tylorstown, Brancepeth and Micklefield Collieries. My father went to the scene of each as soon as possible, examined the bodies of the men and horses, and in one case helped in the rescue of still living men. He concluded that the main cause of death was carbon monoxide poisoning, though a few had been badly burned or killed by the force of the blast.

In a Blue Book published in 1896 he recommended the use of mice as indicators of carbon monoxide. Later he found that small birds were better. But he went further. "In such cases," he wrote, "escape would still be possible were the men provided at their working places with apparatus for maintaining life in irrespirable atmospheres, and were electric lamps available for lighting parties of men on their way out." He then went on to describe the apparatus needed, which was something like the modern mine rescue apparatus or the Davis apparatus used in submarines.

This report was made forty-three years ago, and while escape apparatus is provided for men in submarines, this has not been done for coal-miners, although, if it had been provided, several thousands of lives would have been saved.

My father continued his work on several different lines. Starting from the fact that carbon dioxide causes much more panting than want of oxygen, he showed that the breathing is generally so regulated as to keep the amount of carbon dioxide in the blood very steady, and that it is as bad to have too little carbon dioxide as too much.

He also showed how to make diving much safer, and did a good deal to improve ventilation in mines, ships and factories. In his latter years he was occupied with the question of silicosis. He always said that the most interesting physiological problems were those which arose in ordinary life, and did his best to link up physiology to industrial hygiene as well as ordinary medicine.

From the age of ten onwards, I used to go down mines with him frequently. Besides this, he experimented on me in the laboratory. So it was quite natural that I should carry on his work, and in particular study changes in the blood which took place when I breathed air containing a lot of carbon dioxide. Such experiments are not dangerous if one knows one's job, nor alarming if one has been brought up to it. In fact, the experiments which I made in connection with the *Thetis* disaster were only the continuation of the work which my father began fifty years ago in the slums of Dundee.

SCIENCE APPLIED TO WAR

THE *THETIS* DISASTER[1]

IT is very doubtful whether we shall ever learn the whole truth about the terrible disaster which killed ninety-nine men in the submarine *Thetis*. Even a public inquiry can be hampered by official secrecy. A good many questions have been asked about the delays in salvage, the absence of a diving bell, the failure to use cranes, and so on. These questions must be pressed home.

But there are others concerning the human as opposed to the mechanical side of the disaster, which I am going to ask here. The crew were not drowned,[2] but suffocated. This may have happened in several ways. A doctor said that the rescued men were suffering from carbon monoxide poisoning. I do not believe this.[3] Carbon monoxide arises from incomplete combustion. But presumably the

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[1] This article is reprinted in its original form. Later on I was employed by the A.E.U. and E.T.U. to attend the Inquiry and conduct experiments to throw light on the disaster. However, it is interesting to see how far I was right and how far wrong in the theories which I formed concerning the disaster as the result of reading newspaper accounts of it. The later notes show this.

[2] Some of them were probably drowned when water entered the vessel during the final and unsuccessful attempt to escape.

[3] Here I was correct. I felt bound to refer to this theory, as Mr. Chamberlain had mentioned it in the House of Commons.

Thetis's motors were stopped before she dived. If so, there was no source of carbon monoxide.

I hope that the crew died from exhaustion of the air by their own breathing;[1] because this form of death is not painful. Human breathing produces carbon dioxide and uses up oxygen. A submarine should be equipped with a mixture of lime and soda to take up carbon dioxide, and with a supply of oxygen in cylinders or in chemical combination.

We know that the air was getting bad after twenty hours, when the survivors escaped. But there were 103 men on board, instead of the normal fifty-seven. This means that the air was being used up at twice the usual rate. *Was there twice the usual supply of oxygen and soda-lime on board?*[2]

As I have breathed both air containing excessive carbon dioxide and air short of oxygen till I was pretty well unconscious, I can say that, although the carbon dioxide causes severe panting, it does not give the horrible feeling of pressure on the chest which occurs if one is buried alive, as I have been. But if, as is possible, the crew died of chlorine poisoning,[3] they must have suffered.

When salt water gets into accumulators, the salt reacts with the sulphuric acid in them to make hydrochloric acid. This is then oxidised by the lead peroxide, and chlorine gas is formed. This causes terrible coughing, and the victims finally die from oxygen want because the

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[1] Most of them seem to have died from this cause.

[2] There was no oxygen, and the use of soda-lime had been given up some years before. I was unaware of this fact.

[3] There is not the faintest evidence of chlorine poisoning.

membranes of their lungs are so swollen that air cannot reach the blood.

Attempts have been made to seal up the accumulators so that water cannot get in. Unless this has been fully successful, we must ask the following question: *Were the crew protected against chlorine poisoning either by respirators of the Army type or by something like the rescue apparatus used in colliery explosions?*[1]

The survivors escaped with the Davis apparatus. This consists of a cylinder of oxygen opening into a rubber breathing bag strapped to the man's chest. There is also a box of soda-lime to absorb carbon dioxide. The man breathes into the bag through a rubber tube and a mouthpiece strapped on to his face. His nose is clipped and he wears goggles.

He puts the apparatus on, and with another man, enters an escape chamber. Water is let in, and they then open an outer door and are floated up to the top by the buoyancy of the air in their breathing bags. The outer door is then shut, the water emptied into the bilges, and the next two men enter. At least this is what ought to happen. But about half the men who used the apparatus were killed.

The most probable reason for their death is as follows.[2]

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[1] They were not protected, but at least in this case there was no need for protection.

[2] I was quite wrong here. The men who escaped, or tried to escape, were too near the surface to be in any danger from this cause. I think, however, that I discovered the cause of their death. When men who have been breathing air containing 6 per cent. or so of carbon dioxide for an hour or more start breathing pure air, or oxygen, most of them get very bad headaches and some of them vomit. In the experiment which I conducted with four volunteers from the British battalion of the International Brigades of the Spanish war, Bill Alexander vomited, Paddy Duff and Don Renton had violent headaches, while George

The pressure on a man escaping from a submarine changes very quickly. First of all, the pressure rises as he lets the water into the escape chamber. Then it falls again as he rises to the surface. Now, the increased pressure squeezes the air in his lungs into a small volume, and the falling pressure makes it expand.

If the wearer breathes freely, this does not matter. But if, in his very natural agitation, he closes his throat, there may be such a suction in his lungs as to burst blood-vessels or such a pressure as to drive air from his lungs into the blood. One of the crew of the *Poseidon* was killed in the latter way in 1932. The apparatus includes a vane to prevent the man from rising too quickly.

In fact, the Davis apparatus, though excellent with highly trained men, is no more foolproof than the ordinary kind of parachute. Fortunately, however, it is easier to learn its use than that of a parachute. The parachutist leaves the aeroplane with the parachute closed, and pulls a string to open it after he has fallen some way. So one cannot begin by practising small jumps. But one can learn the use of the Davis apparatus at small depths, and thousands of men have done so in a dummy submarine in a tank at Portsmouth.

Had all the men in the Thetis, *including the civilians, had thorough practice of this kind?*[1] If not, no wonder it broke down. Of course, the cause may have been that, owing to the tilt of the submarine, the water could not

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Ives and I had mild ones. In a longer test, I had an intense headache and vomited. Probably some of the men who tried to use the Davis apparatus vomited, pulled out their mouthpieces, and were drowned.

[1] No. The civilians had had no practice. This may well have been a contributory cause of their death.

be properly drained from the escape chamber.[1] If so, the design was faulty.

Finally, another question must be asked. The safety of men in submarines depends on a number of physiological principles. Thirty years ago the Admiralty employed my father, who was a physiologist, to make submarines safer, which he did, and Sir Robert Davis, the designer of the Davis apparatus, collaborated with him. But physiology does not stand still. *Has a first-rate physiologist been employed in the last ten years to apply modern developments of his science to the safety of submarine crews?*[2] If not, the people must demand that in future research must be carried out on the men as well as the machinery concerned, and that those who are responsible for the omission shall be replaced by others with more respect for human life.

This is a horrible article. I am sorry. But it is about a horrible subject. So long as the nations cannot agree to abolish submarines, brave men are bound to be in danger. But lovers of peace can insist that every step should be taken to reduce this danger to the minimum.

SUBMARINES

OUTSIDE Poland, the heaviest fighting in this war[3] has been carried out by and against the German submarines. They have killed over 1,000 British sailors in the

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[1] This was not so.

[2] I know of no evidence that this is so. Steps are now being taken to remedy this omission.

[3] In the first few months.

Courageous and the *Royal Oak*, besides some hundreds of civilians on merchant ships. On the other hand, several hundreds of the crews of German submarines have been killed and captured.

So we have to understand something about submarines if we are to follow the course of the war. A submarine can be used in war in five different ways. She can attack other ships with gunfire, torpedoes or mines. A shell for a five-inch gun only weighs some 60 lb., whereas a torpedo weighs over 1 ton. So a submarine will generally shell a merchant ship rather than torpedo her. But to fire the gun she must come to the surface and expose herself, and therefore torpedoes are generally used against warships.

A large submarine has six or more torpedo tubes and carries twelve or more torpedoes. A torpedo is really a small self-steering submarine, with 500 lb. or more of explosive in her nose. She has her own engines and rudders, and is kept on her course by a spinning fly-wheel, which acts as a compass.

Some submarines are specially adapted for laying mines. In 1914–18 the Germans used them on a large scale, and one of them accounted for the cruiser *Hampshire* and Lord Kitchener in 1916. As explosive makes up only a small fraction of the weight of a torpedo, but most of the weight of a mine, this means that a mine-laying submarine carries a bigger weight of explosive than an ordinary U-boat. Besides this, submarines have been used as scouts, since they can come to the surface at night, and can listen for enemy ships even when lying on the sea bottom. And occasionally they have been used to land small parties. For example, Sir Roger Casement landed in

Ireland from a German submarine just before the rebellion of Easter, 1916.

Besides this, submarines have been used for two peaceful purposes. A German submarine carried a cargo of dyes to New York before the United States entered the war in 1917. And submarines have been used for measuring the force of gravity at sea. This is done by means of a pendulum. A pendulum clock which keeps time in England will go too fast at the North Pole, where gravity is stronger, and too slow at the Equator, where it is weaker.

This difference is due to the earth's rotation, which counteracts gravity at the Equator to a slight extent. But there are other local variations in gravity. A pendulum in a room swings quicker if you put a few tons of lead in the cellar below it. So it can be used to measure the density of rocks. You can't do this on a ship on the surface of the ocean, because the waves roll it. But it can be done in a submarine well below the surface. And it was first done in a Dutch submarine crossing the Indian ocean. This and later work of the same kind showed that the rocks below the ocean are denser than most of those below the continents.

At the end of the last war the submarine menace had been largely met by the convoy system, by nets, minefields, trawlers and aeroplanes. When the British Government in 1935 made a treaty with Hitler allowing him to build submarines we were told that British ships had little to fear from them. The widows of the men who died on the *Courageous* and the *Royal Oak*, unfortunately, know better by now.

The people will demand to know why these ships were lost. As the *Royal Oak* is said[1] to have been probably sunk "by U-boat action," she may have struck a mine. The *Courageous* was torpedoed. As our larger ships were supposed to be designed so that a single torpedo could not sink them, it may be that several torpedoes were fired at once, and the ship holed in two places; or the charge of the torpedoes may have been increased.

But, above all, we want to be sure that our ships are not being unnecessarily risked. Mr. Churchill is doubtless a better First Lord of the Admiralty than Lord Stanhope. That would not be very difficult. But he was at least partly responsible for one disaster in 1914 and another in 1915—namely, the Antwerp and Dardanelles expeditions. It will be said that, as the German Navy is weak, we can afford to lose ships. That may be, but their crews are human beings. And the time may come when we shall need every ship. If the Japanese militarists realise that they cannot conquer China, they may yet try to regain prestige by attacks on Hong-Kong, Singapore, British Borneo and even Australia or New Zealand.

The announcements made by the Admiralty are intended to assure us that the war at sea is going as well as possible. Certainly we are in no immediate danger at sea. Nevertheless, the *Thetis* disaster showed that our naval authorities can make mistakes—to put it very mildly. It is the business of Parliament to see that lives are not lost unnecessarily. There are men in the Labour and

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[1] It was later disclosed that the *Royal Oak* was struck by several torpedoes from a submarine which had got into Scapa Flow, whose defences were far from adequate.

Co-operative parties, such as Mr. Alexander, Lord Strabolgi and Commander Fletcher, who have the necessary knowledge of naval matters. The people looks to them to see that the lives of our naval and merchant marine are not thrown away.

MORE ABOUT SUBMARINES, AND MR. KEYNES

A SUBMARINE embodies a vast amount of science, and I can only deal with two of the very simplest principles involved. First of all, how is it moved? On the surface by means of Diesel engines burning heavy oil, as in a motor-ship. But once it submerges the engines would use up all the air in the ship in a very few minutes.

Perhaps some day a mechanism like a fish's gills will be invented, by which a submarine can take oxygen out of the sea-water, where it is dissolved, but this has not yet been done. So the propeller is worked by storage batteries, which do not need oxygen, but which take up a large fraction of the total space in the ship.

Our muscles have to adapt themselves in the same way. Normally they take oxygen from the blood which goes through them. But during very hard work, such as a 100-yard sprint or the lifting of a heavy weight, they can work so quickly as to use all the oxygen available, and they fall back on other sources of energy. These don't last long, or we could sprint for a mile.

However, some animals—for example, cockroaches—can carry on for a long time without air, like a submerged submarine. The crew, however, use up the oxygen in the ship very slowly. The *Thetis* sank with a double crew, and two compartments flooded. The men in her were little affected for twelve hours, but were panting very badly after eighteen. This means that with a normal crew and no flooding, the crew could easily last for twenty-four hours, and would be alive after thirty-six or more.

Thus a submarine can safely stay all day below the surface, and come up for air at night, when she is not likely to be detected. The batteries can also be recharged when the engines get air again.

How does a submarine dive? Normally, she has enough buoyancy to float with her conning tower and a narrow deck out of water. To submerge, she lets water into tanks which lie between her outer skin and the inner part where the men live and the engines work. These tanks are open at the bottom only, and by blowing compressed air into them the water can be forced out and buoyancy regained. For this purpose she has a big store of compressed air in steel bottles which are refilled by a compressor worked off the motors when she is on the surface. Like the batteries, these bottles take a certain time to charge, so a submarine cannot be continually altering her trim.

There are two methods of keeping at a given level in a fluid—a statical method, which does not involve motion, and a dynamical method. A balloon uses the statical method, an aeroplane the dynamical. If the balloonist wants to rise, he drops ballast overboard; if he wants to descend, he lets out gas.

But a submarine cannot use this statical method, for the following reason. Suppose it is exactly in equilibrium—that is to say, weighs exactly as much as the same volume of water—when its deck is thirty feet below the surface. If it rises, the air in the upper part of its tanks will expand, so it will lose weight and rise still higher. If it falls, the air will be compressed, and it will lose buoyancy and falls to the bottom. That is to say, the equilibrium is unstable.

But a balloon is in stable equilibrium. If ballast is thrown out it rises to a level where the air is thinner, and gives it less lift than before. It may go past the new equilibrium level, but it soon settles down to it. The equilibrium is stable.

A submarine can only keep its level by moving. As long as it is moving, the commander can make it rise or fall by turning its hydroplanes, which act in the same way as rudders. But a rudder is of no use unless a ship is in motion. Nor is a hydroplane. Now, submarines can be detected by listening apparatus if they are moving. In shallow water they can lie on the bottom. But they cannot go down to the bottom of a deep sea, as the water pressure would crush them. This gives their hunters a great advantage.

The difference between a stable and an unstable equilibrium is very important in politics and economics. The bourgeois economists pointed out that a society would be in economic equilibrium if production just balanced consumption. This is true; but Marx showed that under capitalism the equilibrium is unstable, like that of a submarine, and not stable, like that of a balloon.

During a boom, more commodities are produced than consumed. Then comes a slump. The surplus commodities may be slowly used up, deliberately destroyed, or used for war purposes, if, as at present, a war takes the place of an impending slump. In order to overcome this instability, the community has to control production, as the commander of the submarine controls his ship. So far this has only been done in the Soviet Union.

Of course, there are economists like Mr. Keynes who believe that a capitalist economy could be controlled. Perhaps Mr. Keynes could prevent booms and slumps if he were allowed to. But so long as the State is in the hands of capitalists, they will not take his advice, which would limit their profits very severely. As soon as we understand the Marxist theory of the State, we see why all schemes for a planned capitalism are Utopian, and economic stability is only possible when the workers have gained control of production.

WHAT IS AN EXPLOSIVE?

It is a good general rule that the more we know of a thing the less we fear it. So to win the war we had better understand as much as we can about the scientific principles involved. Let us begin with explosives. They are used for three purposes; as propellants to make bullets and shells move quickly; for destruction, in high explosive shells, torpedoes, mines and bombs; and for scattering in shrapnel shells, where a small charge drives the bullets out so that they fall over a wide area.

The first explosive was gunpowder. This is a mixture of three substances, saltpetre (potassium nitrate), charcoal (carbon) and sulphur, none of which is explosive alone. But the potassium nitrate is mildly unstable, and can easily give up some oxygen to burn the carbon and sulphur. A good many other explosives are mixtures of the same kind.

In fireworks the nitrate is often replaced by a chlorate of some metal, which also gives up oxygen easily. The I.R.A. terrorists used potassium chlorate. In 1914–18 the French used an explosive called "cheddite," which is easily made where large amounts of hydro-electric power are available, and contains ammonium perchlorate. Ammonal, which includes aluminium powder, is another mixture.

In the nineteenth century a new type of explosive was produced. This is not a mixture, but a compound, that is to say a substance in which all the chemical molecules are of the same kind. In gunpowder the carbon is in one molecule, the oxygen in another. In nitro-glycerine the carbon and oxygen are in different parts of the same molecule, and have a much smaller distance to move before they can unite. In Marxist terminology, the internal contradiction in the explosive is further developed, and the effect when it is resolved is more violent than in the case of gunpowder.

Every explosive acts in the same way, by suddenly generating a big volume of hot gas at high pressure. Something has to make way for it. But there is a fairly sharp distinction between "low" and "high" explosive. A high explosive may liberate less heat, and less gas, than a low explosive, but it does so much more quickly.

When a soldier fires a rifle, he starts a rearrangement of the atoms in the cordite filling of his cartridge. This liberates hot gases which drive the bullet forward. But they are given off relatively slowly, and are still being formed when the bullet is half-way along the rifle barrel.

If a traitor had substituted a high explosive, such as gelignite, for the cordite in the cartridge, much the same amounts of heat and gas would be produced. But they would be produced almost instantaneously, and would cause such a high pressure as to burst the rifle barrel and probably kill the soldier. On the other hand, the pressure on the bullet would be over in such a short time that it would not leave the rifle at as high a speed as with cordite.

So low explosives such as gunpowder and cordite are used for propellants, and in land mines where the object is to lift a large volume of earth rather than to shatter a small volume. For most other purposes, high explosives, such as trinitrotoluol, are used.

Another distinction among explosives depends on the method of setting them off. Some explosives, such as gunpowder and mercury fulminate, are set off by a spark. Others, such as guncotton and trinitrotoluol, are much harder to start off, and this is usually done by a detonator, containing a small amount of a sensitive explosive, such as mercury fulminate or lead azide.

There is no necessary connection between the ease with which a substance can be got to explode and the violence of the explosion. If anything, the other way round. The same is true of revolutions. It is easy to make a revolution in most South American states, but nothing much comes of it. It was very difficult to overthrow the Tsar, but the results of doing so were tremendous. It will not be easy for the German people to overthrow Hitler, but when they do so a new era will dawn for the whole of Europe.

A very large amount of work has been done on explosives, and scientists who have worked on them are blamed for making war more terrible. This is a false accusation. Modern wars are terrible because transport enables millions of men to be concentrated in a single battle.

If explosives had never been invented, and the Germans were invading Poland with swords and spears, there would be just as much bloodshed as there is to-day, provided they had motor transport. If the Siegfried Line was a wall like the Roman Wall in Northumberland, it would be a formidable obstacle if it were defended by millions of soldiers against an army without explosives.

And without explosives many forms of mining and quarrying would be impossible. Indeed, mining has had as much influence as war on the development of explosives. Explosives are not good or bad in themselves. They are good or bad according to how we use them.

DEATH RAYS

I AM constantly getting letters describing remarkable inventions for protection against air attack. Some of them may be of value, but I cannot judge of their merits. The great majority can be rejected at once because their authors have clearly not thought in numbers, but in words or pictures.

Some people want to let loose large amounts of a gas which will be lit by bombing aeroplanes which fly into it.

The mixture would have to be just the same weight as air, unless it was to rise into the stratosphere or fall to the ground in a few minutes. And it would have to be produced in volumes measured in cubic miles. As a cubic mile of air weighs 2½ million tons, this form of defence would be hopelessly expensive if it were possible. And 1 million tons of gas exploding over London would be worse than a dozen air raids.

A favourite invention is some form of "death ray." There really are death rays. Ordinary X-rays can kill people, and have killed quite a number. So-called soft X-rays, which have a relatively long wavelength, are stopped by the skin. In small doses, they make the hair come out, and are used for treating ringworm in children, as it soon grows again. But large doses cause ulcers which may develop into cancer.

"Hard" X-rays, with a shorter wavelength, penetrate the tissues. Some may go right through, and are used for photography. But a certain proportion are stopped, and may damage the tissues. They are particularly dangerous to quickly dividing cells, such as those of cancers and unborn babies. But in large enough doses they can injure any organ.

Thirty years ago the idea of a death ray was not unreasonable. New sorts of rays were constantly being discovered. Some were harmful, and it was reasonable to hope or fear that a really deadly one might be found. But now we have studied radiation of all kinds, from long radio waves to the short-waved gamma rays produced by radium, and none of them are very deadly.

What is more, the moderately deadly ones, such as

X-rays, cannot be used over long distances, because they are stopped by air. There is a good reason for this. We have to be immune to any kind of ray which can reach us from the sun. Earthworms are killed by ordinary sunlight in a few hours, even if they are kept cool and damp.

And as if to show that human beings are not necessarily any better off, children are occasionally born who are very sensitive to sunlight. In the case of one disease, they blister in the summer; in that of another, they develop freckles which later become open sores and kill them. Natural selection, therefore, prevents anyone from being too sensitive to sunlight, and gives dwellers in the tropics a special protection in the form of skin pigment. But it does not protect us from rays which come from the sun, but are stopped by the upper air.

So we can be fairly sure that any very deadly ray would be stopped by a few miles of air, and would therefore be useless as a defensive weapon against aeroplanes. Another suggested use of rays is this. When a strong beam of ultra-violet radiation passes through air, it makes it conduct electricity. Why not shine such a beam on to an aeroplane and pass a current along it? Or, better still, why not pass the current along one beam and let it return to earth by the other, making a lightning flash between them, which would destroy the aeroplane!

The answer is simple. The air conducts because it is ionized. That is to say, electrons are torn out of the molecules and can carry a current. This happens in the upper layers of the air, which reflect radio waves downwards. But to make air conduct, work must be done on it. That is to say, the energy of the ray must be used up.

This kind of death ray works to some extent in a laboratory. In the 1914–18 war an inventor even claimed to have killed a mouse with one, and he thought that a more powerful one might kill a man. The fallacy is as follows. It is hard enough to get a beam which stays parallel and does not spread out like the beam of a searchlight. But let us suppose that this can be done.

A beam which used up half its energy in going through 10 feet of air would work nicely in a laboratory. Now suppose it were directed on to an aeroplane a mile off. The energy in it would be halved 528 times. That is to say, to kill a mouse a mile away, you would need vastly more power than to kill one 1 foot away. Actually, the power must be multiplied by a number of 159 figures; in fact, all the engines in the world could not begin to produce it.

The passage from a model to a full-size machine is often difficult, and sometimes impossible. It is just the same in human affairs. Some people think that because most families can get on by goodwill without any special organisation, a nation of many millions, or even the whole human race, ought to be able to do so.

Certainly we shall get on much better when we have abolished classes, and when no nation is governed and exploited by any other nation. Probably nothing like the present State organisations will be needed, but the anarchists' theory of a world with no compulsion is as far removed from practice as are some of the inventions which I have described.

BARRAGE BALLOONS

Now that we are at war, we may as well try to understand as much about it as the Government will let us. Perhaps the most familiar feature of it to Londoners is the balloon barrage, intended to keep bombers at a height, so that they cannot aim accurately. However, I am not going to write about their use in war, but about the scientific principles involved in their construction and use.

A cubic foot of air weighs about $\frac{7}{10}$ oz. You can't weigh it directly. But if you weigh a large bottle holding a cubic foot, pump out the air, and then weigh it again, you find that it has lost this amount of weight. But the bottle has to stand a pressure of 15 lb. per square inch, so no one has yet been able to combine the needed strength and lightness and get an empty bottle to rise into air.

The pressure must be the same inside and outside the balloon, but the gas inside the balloon must be lighter than the air outside. Montgolfier's first balloon was a paper balloon filled with hot air, like those which one can buy in toyshops. If you heat air from 32° F. to 212° F.—that is to say, from the freezing-point to the boiling-point of water—it expands to 137 per cent. of its former volume. That is to say, 1 cubic foot loses 27 per cent of its weight, and has therefore a lifting power of about $\frac{1}{5}$ oz. per cubic foot.

Though Pilâtre de Rozier went up in a basket lifted by a hot-air balloon, it was soon found that hot air was not only dangerous (since balloons sometimes caught alight), but inefficient.

Hydrogen is the lightest of all gases, and 1 cubic foot of hydrogen weighs less than one-seventh as much as 1 cubic foot of air. So a hydrogen balloon has six-sevenths of the maximum lifting power which is possible. A captive hydrogen balloon was first used in war by the revolutionary armies of the First French Republic at the Battle of Fleurus in 1794, just as in our own day the Soviet Air Force were the pioneers in landing troops from parachutes.

But hydrogen was very expensive. It had to be made on the spot by pouring sulphuric acid on to scrap iron. It is cheaper to-day for two reasons. It is generally made by the Lane process, which is as follows. A special type of iron ore is heated in a current of producer gas from partly burnt coal, which unites with some of the oxygen in the ore and leaves iron behind. Steam is then passed over the red-hot iron, which takes back oxygen, leaving hydrogen behind. The process can be repeated a number of times.

And the gas can be stored under pressure in cylinders, so we do not have to have a miniature chemical factory attached to each balloon. Of course, the design of these cylinders involves a very great deal of experience and they could not possibly have been made a century ago. If you doubt this, try to make a tap which will stand very high pressures and yet open easily.

The balloons are, of course, as gasproof as possible, and they are painted a silvery colour so as to keep their temperature as constant as possible. The sun beats down on them, and if they were black they would absorb most of the heat in its rays. Any other colour would absorb less, and one which reflects most of the rays absorbs least of all.

Fortunately, the principle works the other way at night. A black body gets rid of heat by invisible heat rays, and a silvery body radiates far less. If the balloons heat up by day and the gas expands too much, they must burst or lose gas. If they cool by night, they lose lifting power and therefore cannot rise so high.

The hydrogen in the balloon has not only to lift the fabric, but the cable. The upper part of the cable has to lift the lower part, but the lowest part of the cable has no weight to lift, though, of course, it must be able to stand strains due to the wind. Consequently the upper part has to stand much greater pulls than the lower part, and in theory at least it has to be thicker.

Ideally, then, the cable should taper from above downwards, like the stalk of a pea plant, or at least be composed of sections increasing in thickness as they go upwards. I have, of course, no idea whether this is done in practice.

A lot of nonsense is talked about balloons. Some people think that they might explode if they were struck by lightning or hit by an incendiary bullet from a hostile plane. This is quite untrue. Pure hydrogen does not explode, but burns fairly quietly. To explode, it must be mixed with a lot of air, and this cannot occur, as the leakage is almost entirely outwards.

Others think that a burning balloon might fall on a house. This again is unlikely,[1] as the flames would tend to keep it up, and the fabric, which might fall when the gas had escaped, is not very inflammable. Other alarmists think that a drifting cable might knock houses down, whereas at worst it could only break a few skylights.

We must realise that quite a light cable may be fatal

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[1] But it has happened. No serious damage was done, as the burning gas went upwards.

to an aeroplane hitting it at 250 miles per hour, and yet harmless when pulled along at a tenth of that speed. We do not yet know, and shall not know till a raid has occurred, just how much safer these balloons make us, but they certainly make for greater safety, instead of the reverse.

TWO CURIOUS HAPPENINGS

Two curious events were recorded in the Press in February, 1940. A couple of patients at the Haslar Naval Hospital were killed because they were given a poisonous gas instead of an anæsthetic. And there was a scare in a number of East Coast towns to the effect that small rubber balloons which were seen in the air contained poisonous gas. In one town people were told to wear gas-masks.

Both these events were symptoms of ignorance in people who should have known better. The patients at Haslar were to have been given nitrous oxide, or "laughing gas," which would have made them unconscious. They were given carbon dioxide, which killed them. Someone had painted the carbon dioxide cylinder with the colour generally used on nitrous oxide cylinders.

A relative of one of the victims said it was murder. I should not go so far as that, but I should like to know why the gas cylinders were not carefully examined after the first patient had died or, at least, become very ill. It was reasonable to have a cylinder of carbon dioxide on the spot, but I should have preferred a cylinder containing a mixture of oxygen with about 5 or 6 per cent. of carbon dioxide.

Here is the reason. Anæsthetics act by putting the upper part of the brain, which is concerned with consciousness, out of action. But they have some deadening effect on the lower parts of the brain which are concerned with unconscious actions.[1] This must not go too far, or breathing will stop. For breathing, digestion, pulse rate and many other internal activities which go on without our wills are regulated by the brain.

My father discovered that normal breathing is regulated by the amount of carbon dioxide in the blood. Most people stop breathing for a while if they breathe as quickly and deeply as they can for a minute. This is not because they are tired of it, for if you over-breathe with air containing 4 per cent. or so of carbon dioxide, you do not stop breathing afterwards. It is because when you over-breathe in ordinary air you wash carbon dioxide out of the blood, in which it is dissolved, but this does not happen when you breathe a little carbon dioxide.

Now, after an operation people often look green in the face. This is because their breathing has slowed down, and so their blood is not getting a proper supply of oxygen. It is possible to stimulate the part of the brain which regulates breathing by injecting a drug into the blood. But Professor Yandell Henderson, an American colleague of my father's, saw that it would be safer and quicker to use the natural stimulus—namely, carbon dioxide.

The four International Brigaders who helped me in the experiment in connection with the *Thetis* will never forget how they panted when breathing air containing nearly

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[1] See p. 53

7 per cent. of carbon dioxide. Henderson does not recommend giving it quite so strong. But he gives enough to wake up the respiratory centre of a brain which has been put to sleep by an anæsthetic. And this has saved many lives.

If I had been in charge of the gas cylinders at Haslar, I should have opened them and had a sniff at each. Nitrous oxide has a sweet taste, while air containing a little carbon dioxide makes you pant, and air containing a lot makes you choke and has a sour taste. Try breathing the gas that comes out of soda water or "mineral" water.

But I dare say that if I had opened the cylinders I should have got the sack or at best been told to mind my own business. Workers are always more efficient, and particularly so when something goes wrong, if they understand every detail of their job, even those which don't generally concern them. But under capitalism they are not encouraged to know too much. Lenin wanted to build up a nation of people "who can do everything." Capitalist employers are apt to prefer men who are reduced to the level of machines.

If the men in charge of the warden service on the East Coast know anything about gas warfare, they must know that in order to float in the air, a balloon must be filled with a gas lighter than air, such as hydrogen, and that no gas which is lighter than air is seriously poisonous. But they might have argued that the rubber balloons contained a mixture of a light gas, such as hydrogen, with a little of a heavy and poisonous one, such as arsine.

Even so, there would have been no real danger if one of the balloons burst in the open. For it takes a big volume of gas to kill a man. If you breathe air containing 1 part of chlorine in 5,000 for ten minutes you will probably die. But within this time about 100 cubic inches of chlorine will have gone in at your mouth and nose. You might possibly get as much as this from a small rubber balloon if you took it into a room and opened it. You could not do so in the open.

You may say that people cannot be expected to know things like this. I answer that practical thinking is almost always quantitative. A good farmer can judge the weight of an ox; a good mechanic knows what strain a tool will stand. A good warden, if he or she has been properly trained, will think accurately about quantities of gas.

Probably the rubber balloons were from a meteorological station and used to observe the speed of the wind at different heights. These balloons are filled with hydrogen and watched through telescopes. From the directions of two telescopes the position of a balloon can be calculated, and thence the Air Force can be informed of the wind speed. When the hydrogen leaks out of the balloons they come down to earth again.

The more that wardens and other A.R.P. workers are told about every detail of defence which is not absolutely secret the better. And the use of small balloons is described in every book on meteorology. If wardens do not know such things, they will make mistakes. Even a false alarm is dangerous, for it will lead people to disregard signals if real air raids start. Science means knowledge, not secrecy, and scientific medicine and scientific defence demand that knowledge should be as widespread as possible.

SMOKE

ONE of the weapons which have helped the German armies to victory in France has been smoke. So far they have not used poisonous smokes, but they have screened their attacks in immense clouds of smoke which hid the sun for many miles behind the French lines and concealed their tanks until it was too late to fire at them.

A smoke is a collection of particles, either solid or liquid, of a certain degree of fineness, suspended in air. When the particles are large enough to be visible, as in the case of dust or coarse mist, they fall fairly quickly. Very small particles, such as molecules of a vapour, stay suspended indefinitely, while smoke may hang about for days.

Just the same is true of suspensions in water or any other liquid. Very small particles, such as molecules of sugar, are dissolved. Very large ones form a mud which soon settles if it is heavy. But intermediate particles, such as those in milk, blood, the milky fluids which you get by mixing some disinfectants with water, or solutions of gum or egg-white, settle very slowly if at all.

These intermediates are called "colloidal solutions" or "suspensions," and have very interesting properties. If the particles are about the size of a wavelength of light or a little smaller, they scatter light in a peculiar way. The same smoke looks brown when you see the sun through it and blue when you see the sun shining on it.

This is because the blue rays in the sun's white light are more scattered by the smoke particles than the green, yellow and red rays of longer wavelength. Colloidal suspensions in water often behave in the same way.

Smoke particles keep up in the air because they are constantly colliding with the molecules of air, and this prevents them from falling. They may lose their motion and stop on hitting a solid, particularly if it is cold. That is why smoke often condenses on the plaster of a wall where it is cooled by a water pipe.

Smoke particles generally have an electrical charge which keeps them apart from one another, and prevents their coalescing into particles of soot. One way of condensing smokes is by attracting them to something of an opposite electric charge. Another is by mixing them with a smoke whose particles have the opposite charge.

It seems likely that the chemists and physicists employed by the Nazis have been studying smokes pretty intensely. The French and British troops could not see through the smoke clouds in France. But it is possible that some of the Nazis could. For smoke which will stop visible light rays will often let through infra-red rays, with which photographs can be taken. If these photographs could be developed in a few minutes, this might be extremely advantageous.

Among the most interesting of smokes are those of arsenical compounds, such as diphenylcyan-arsine. These are made by heating the compound in question, and are mostly only moderately poisonous, but intensely irritating to the nose.

They will go through the charcoal filter of a gas mask, but are stopped fairly completely by felt pads. The attachment recently issued for respirators is intended to stop smokes. It will probably stop most of the known types of poisonous smoke. But if the Nazis have been able to produce a smoke with finer particles than those used in the last war, some of these may get through.

If so, they may cause irritation of the nose, and sneezing, but even if they do it will be better to keep your respirator on if you can, for even a bad respirator stops most smoke particles. One ground for fearing that the Nazis may use arsenical smokes is that they bought up large amounts of arsenic in 1938 and 1939.

The possibility that smoke may be used is one reason why all air raid shelters should be provided with curtains which would render them moderately smoke-proof and gas-proof during a raid where smoke or gas was used.

It is possible, though I think rather unlikely, that a smoke may have been invented which is not merely irritant, but deadly, in the relatively small amounts which could be used in an air raid. It seems more likely that arsenical smokes would be psychological weapons, like the attachments to bombs which make them howl as they fall.

I shall no doubt be accused of spreading panic in this article. I don't agree. I would much rather be attacked with poisonous smoke than with the same weight of high-explosive bombs. Panic is very often caused by fear of what we do not understand.

That is why Marxists, who understand how and why the British people has been dragged into its present terrible situation, and also understand the way out of it, are the last people who are likely to yield to panic to-day. And the more they know about every possible weapon, the better they will be able to stop panic among their neighbours.

CAMOUFLAGE

We have all seen factories and other buildings painted in patches of various colours designed to make them invisible to the pilots and observers of bombing aeroplanes, and also buses and military vans similarly decorated.

The principle of what is called "procryptic coloration" has long been recognised by biologists. It is fairly obvious that a polar bear or a white rabbit is inconspicuous against snow or ice, a yellow lion or antelope against sand or dry grass. Some animals even undergo seasonal colour changes which are adaptive. Thus the stoat, when exposed to cold, changes its brown fur to white, and is called an ermine.

Besides these, there are, of course, a number of conspicuously coloured animals. Sometimes this colour is supposed to be a warning to enemies, as with the black-and-yellow stripes of the wasp. In birds the male is generally more brightly coloured than the female. Darwin thought that this was because females preferred the brighter males.

In some cases he was right. But not always. The cock robin uses his red breast as a display or threat to warn off other cock robins rather than to charm his wife. In other cases it is thought to be an advantage to the species that males rather than females should be attacked. But, frankly, biologists are still quarrelling about the advantage, if any, of some conspicuous colour schemes.

The standard type of protective coloration can be seen in rabbits, mice, female wild ducks, and many fish. Here the back is of a neutral greyish brown colour, gradually shading off to a white or pearl-grey belly. If you look carefully at a wild rabbit skin, you will see that the hairs on the back are black with yellow bands.

Now, if we make a stuffed rabbit, but cover its belly with skin from the back of a second rabbit, it is all pretty much of one colour, and very conspicuous. For the lower parts are in shade, and so appear darker than the back. But in a real rabbit the light colour of the belly roughly compensates for the shadow, and it is much harder to see.

Thayer, an American naturalist, was the first to point out this simple principle. But it is desirable that the dark top should shade gradually into the light bottom. Very little notice is taken of this principle in the camouflage of vehicles, which should be hidden from bombers as hares are hidden from hawks.

Besides this pattern, or instead of it, many animals have a pattern of stripes or spots which looks conspicuous in a museum or zoo, but actually hides them in Nature. The leopard, cat and zebra are good examples. Finally, especially among insects, we find structural camouflage. The animal's shape is such that it looks like a leaf, twig or thorn, and is very hard to pick out in suitable surroundings.

In the last war structural camouflage was first developed by French artillery officers, who hid their guns under nets to which bits of cloth were attached, so that they could not be seen from aeroplanes. The use of paint was probably first suggested by a zoologist, Professor Graham Kerr, who recommended, not only counter-shading of ships, but disruptive or "dazzle" painting, as in the zebra, which makes it hard to see the exact shape of the animal or ship.

One would suppose that, since the principles of camouflage in animals were worked out by zoologists, the Ministry of Home Security might have invited zoologists to assist in the design of camouflage for buildings and vehicles. Up to August, 1939, Sir John Anderson refused to do so, and when two scientists were finally asked to serve on this Committee, they very soon tendered their resignations, since their opinions were disregarded.

The whole matter has recently been raised in the leading scientific weekly, *Nature*. I am told that Sir John Anderson has been unsympathetic to some of my own suggestions on A.R.P. because I am a "Red." He has been no more willing to listen to Professor Graham Kerr, though he is now a Conservative M.P.

According to *Nature*, the Civil Defence Camouflage Establishment has sixty-five technical officers, mostly artists or art students. Not one is a biologist.[1] The results are serious. Differences of colour such as those between the dull greens and browns of service vehicles are useless for two reasons.

The colours are of much the same tone, yet "mere differences in tint become invisible at a short range, and objects so coloured are virtually self-coloured and hence

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[1] An artist employed on camouflage wrote to the *Daily Worker* under the impression that I was attacking his profession, and stated that artists had already raised all the points in this article, but in vain. I certainly do not wish to attack artists or art, but I still think that one biologist and one psychologist might have been included in the sixty-five.

self-evident." Everyone knows that most colours fade into blue and brown at a distance. It is also likely that German bombers use colour screens, such as were attached to the periscopes of German submarines in 1914–18.

Ships are no longer dazzle-painted. The author of the article in *Nature* regards this as a grave mistake. It may be, however, that even if dazzle painting makes it harder for an observer in a submarine to tell how large a ship is, and which way it is moving, it renders it more visible from an aeroplane. Even if this is so, the lesson of zoology is clear that ships should not be painted a uniform grey.

I might be accused of spreading "alarm and despondency" if I quoted the more biting passages from the article in *Nature*, so I will content myself with the statement, with which I am in full agreement, that "much contemporary effort at camouflage has failed utterly and is consistently failing to obtain effectiveness."

If this is true, numerous factory workers will be needlessly killed when daylight raids begin. The camouflage scandal is one of very many cases where, owing to the smug complacency of the men in power in the Cabinet and Services, scientific knowledge is not being applied to defence. Owing to the Official Secrets Act and the Emergency Powers Act, I cannot write about still more serious failures to use existing knowledge.

Scientists are not infallible. And in all countries but the Soviet Union, they are apt to be unpractical because they are kept in laboratories and secluded from ordinary life. But where scientific principles are involved, they should at least be consulted before decisions are made on which thousands of lives depend.

INDUSTRIAL HEALTH IN WAR

SPEED UP IN THE FACTORIES

ONE of the many lies which are being spread concerning the *Daily Worker* is that it is trying to sabotage the industrial effort in connection with the war, especially by leading the fight against long hours and low wages.

Now, sabotage means damaging machinery. If you are in charge of a lorry and drive it till the water in the radiator boils away and the engine heats up and seizes, the first time it may be due to mere ignorance. But if you do it a second time, after being warned, a charge of sabotage would be reasonable.

I have just been reading the report of the Health of Munition Workers Committee, presented to Mr. Winston Churchill in 1918, and summing up the experiences of the last war. The Committee which drew it up included only one trade unionist out of eleven members, so it can hardly be accused of bias in favour of the workers. I have also been reading the daily Press.

Last Sunday[1] many thousands of workers carried on. Yet the Committee unanimously found that "the evidence proves conclusively that Sunday labour is unpopular, uneconomical and not productive of increased output. . .

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[1] In June, 1940.

Where Sunday labour becomes necessary, arrangements should be made, by a system of relief shifts, that no individual worker is employed more than six days in the week."

It seems to me that politicians who enforce a seven-day week and trade union leaders who accept it are sabotaging the war effort as effectively as if they were overdriving a machine. I am a materialist, which does not mean that I think men are machines, but it does mean that I think men and women should be at least as well treated as machines.

In a great emergency Sunday labour may be permissible in a few factories, but if it is made general, it will merely lead to lessened production within a few weeks, partly through lessened output per hour actually worked, and partly through bad time-keeping.

The same arguments apply in many cases to length of hours. An extremely interesting report was made in 1920 by Dr. Vernon to the Industrial Fatigue Research Board on the effect of reducing hours on output. There are very full data on a group of women turning aluminium fuse bodies from 1915 to 1917.

For the first twenty-four weeks, they were supposed to work a seventy-four and a half hour week, though actually their average, owing to sickness and other causes, was sixty hours. Then the hours were cut to sixty-three and a half. For four weeks the output did not rise. Then the hourly output rose to 131 per cent. of the former average, so that in the shorter time they actually made 12 per cent. more fuses.

After another thirty weeks, Sunday labour was abolished, and they worked for a nominal fifty-five hours, but actually averaged forty-eight. The hourly output went up slowly, until after seventeen weeks it was 69 per cent. above the level at the beginning. Thus, in a fifty-five-hour week, they made 27 per cent. more fuses than in a seventy-four-hour week. Many other similar cases are officially recorded.

Probably still shorter hours would have given a still higher output. The seven-hour day of the Soviet Union is not only more humane than the ten- or twelve-hour day of capitalism. It is more efficient in a great many industries.

There are other reasons against hours so long as to leave no time for leisure. Men are paid piece rates as an incentive to increased output. But, writes the Committee: "If employers take up the whole of their operatives' time in the factory, they should not be surprised to find that even the best-devised wage scheme fails to act as an incentive."

Lastly, we come to the question of holidays. Most of us lost our Whitsun rest. I took my two and a half days off without hesitation, because I am doing work for a Government Department which I find very exhausting physically, and I knew I needed a break.

But most workers could not do so, and some of them are wondering when they will next get one, let alone three or four days off. Yet "the Committee consider it most important that the ordinary factory holidays should be maintained. The evidence leaves no doubt as to the beneficial effect of such holidays both on health and output."

The completest studies of the physiology of work are probably those from the great institute at Kharkov, where this subject is studied. As I cannot read Ukrainian, this article is necessarily not so complete as it should be. But I can read English and so can Mr. Bevin. And the facts about hours and output discovered in the last war are printed in plain English.

Why are our rulers sabotaging the war effort as surely as a trainer would sabotage a mile race if he told a runner to sprint the first 100 yards? Partly, no doubt, as a result of fifth-column work. But largely through sheer blind hatred of the workers, like the blind hatred of the Soviet Union which nearly forced Britain into war with it.

Those trade union leaders who help them are not only giving up the rights which the workers have won in a century of struggle. They are taking a course which will, within a few weeks, slow down the production of munitions.

A few years ago I should have found such conduct utterly inexplicable. But my experience, while attempting to obtain protection for British civilians from German bombs, have shown me that there is not a great deal to choose between Tory and Labour leaders. And the reading of Lenin's works has shown me why this is so.

T.N.T. POISONING

In the course of a war some munition workers are bound to be killed by explosions. If safety regulations are strictly adhered to, these deaths can be cut down considerably.

But explosives also kill a great many workers by poisoning them. We do not know how many died from this cause in 1914–18, but we can get some idea.

In 1916 and 1917 370 cases of jaundice due to trinitrotoluene were notified, and ninety-six died, whereas from 1920 to 1930 there were six registered cases and no deaths. No doubt some other deaths of workers from this cause were not reported. And this is only one of the ways in which explosives may poison one. Besides the fatal cases, there were very many more cases of serious ill health, and thousands of lives must have been shortened by poisonous explosives.

In this article I shall only deal with trinitrotoluene (T.N.T.), which is not only used by itself for filling shells and bombs, but is a constituent of many other explosives, such as amatol and others since developed, of which, in view of the Official Secrets Act, I cannot write.

In 1914–18, workers both in explosive factories and shell-filling factories suffered from three forms of illness from T.N.T. The commonest is cyanosis. The red blood pigment is partially altered, the face becomes pale and the lips blue. The symptoms include breathlessness, giddiness, drowsiness, weakness and a short period of abnormal hunger, followed by loss of appetite.

Cyanosis is rarely fatal, but may be a forerunner of fatal disease. Some workers died of anæmia, but most of the fatal cases were due to jaundice, as a result of liver damage. These diseases, and the methods of preventing them, are described in a report by Dr. Moore to the Medical Research Council (Special Report Series, No. 11), published in 1917. I wish that every shop steward in an explosive or filling factory could read it. If so, many lives would be saved.

Dr. Moore's first task was to find out how the poison was absorbed. The fumes do not seem to be dangerous. "We have never seen finer, larger and fatter white rats," wrote Dr. Moore, "than those of one set after six months' exposure over the Woolwich melting pots." Nor is dust inhalation very important, though, of course, it should be avoided. This is particularly important to-day, as, owing to the black-out, standards of ventilation are worse than they were twenty-five years ago.

The main channel of absorption is through the skin. After rubbing T.N.T. into the palms of his hands for some hours, Dr. Moore developed symptoms of poisoning from which he recovered at the time, but which may have been a cause of his premature death in 1920. If so, he had saved scores of lives at the expense of his own, for by 1918 the workers' death rate had been reduced to one-quarter of that in 1917.

The first precaution to be taken is the use of filling machinery which makes contact with the explosive unnecessary. Gloves seem to be little use, as the explosive gets inside them. But boots are valuable. Girls should never wear open shoes, but, if possible, high boots and trousers *outside them.* Clothing should be changed in the factory, so that T.N.T. is not taken home, and workers with T.N.T. should use separate cloakrooms, with ample washing facilities. Some protection to the hands can be given with a casein varnish which was much used in 1916. As I have recently seen munition workers with their hands stained a deep orange-yellow colour from explosives, it is clear that these precautions are not being taken to-day. As the danger is greater in hot weather, proper protection is an urgent need.

It is not only the workers, but their families, who are endangered. "We have seen," wrote Dr. Moore, "the skins of infants and little children in the homes, who have never been near the factory, deeply stained from contact with the persons and clothing of their parents, and the hair of wives stained the characteristic auburn brown from powder communicated from their husbands."

The second line of defence is the inspection of all workers, and the transfer to other work of those who show any symptoms of poisoning. For even when the skin is stained, only 5 to 10 per cent. of workers absorb much T.N.T. into their blood. This can be detected in two ways.

Some of the absorbed T.N.T. is eliminated in the urine, and a simple chemical test invented by Mr. Webster and described by Dr. Moore will detect those workers whose skins are most permeable. This test was carried out as a routine in many factories from 1916 to 1918.

Besides this, the first symptoms of pallor in the lips or yellowness in the whites of the eyes should be watched for. "The picking out is not a difficult task; it scarcely even requires medical skill," wrote Dr. Moore; "there is a foreman and forewoman who are right nearly every time they send them to me. It . . . cannot be done efficiently by a visiting surgeon calling once a fortnight or once a week. The excitement of going to see the doctor . . . tones up the patient and disguises the symptoms."

Here is a job for the shop stewards. They will find it hard to make some workers admit that they are ill. Dr. Moore noticed a girl with blue lips. "I told her I was certain she had a mild attack of T.N.T. illness, and that she ought to take a time off work. She started weeping, and said she was the only support of her father, who was aged and unable to work." Dr. Moore let her work for two more days. She got much worse, and died of jaundice a few weeks later.

It must be emphasised that of the workers who go blue only a fraction die of jaundice or anæmia. But the blueness is a danger signal which shows that they are absorbing the poison. Dr. Moore was entirely opposed to the alternation of workers between T.N.T. and other explosives, which merely doubles the number exposed to danger.

Some will say that because there is a war on, munition workers should take risks like soldiers. The official report states that "if the worker is susceptible . . . then that worker is an unsound economic proposition from the factory's point of view." The attitude which treats workers as "hands," not human beings, is one of the many things which make capitalism inefficient.

MORE POISONOUS EXPLOSIVES

Before I begin this article, I must answer a criticism on the last. Some workers say, "What is the good of writing about trinitrotoluene. I am working with a stuff called XY [those aren't the real initials] and want to know if that is poisonous." Now, I can't answer this question.

Sometimes I know what a fancy name stands for, but can't state it, because of the Official Secrets Act. Sometimes I don't.

It is up to the workers, through their union officials and shop stewards, to find out the ingredients of the mixture with which they are working, so that the right precautions can be taken. Of course, this would be easier if workers were taught chemistry at school, instead of dates of kings.

In the manufacture of a great many explosives, nitrogen peroxide, or "nitrous fumes," is given off. This is a brown gas which acts in the same way as chlorine and phosgene, by inflaming the lungs. After gassing, a worker can generally carry on for some hours, and then develops pneumonia, which is often fatal.

The Government has refused to publish the number of deaths from this gas in 1915 and 1916. In 1917 and 1918 it killed twelve and injured eighty-nine seriously and an unknown number slightly. To avoid such deaths, proper ventilation is essential, black-out or no black-out.

Besides this, no one should go near a place where fumes are escaping without a very good respirator or, better, a helmet connected by a hose to a compressed air main. This applies not only to the manufacture of explosives, but to that of nitric and sulphuric acids.

Tetranitromethane occurs fairly commonly as an impurity in T.N.T. and other explosives. Both its smell and its effects on the lungs are much the same as those of nitrous fumes. Every explosive worker ought to be familiar with this smell and to regard it as a signal of very grave danger.

Benzene (benzol) and toluene (toluol), which are used as raw materials for explosives, both give off poisonous vapours, which are treacherous poisons because they are not very irritating. When large amounts of benzene vapour are inhaled, they cause giddiness, unconsciousness, and a peculiar twitching of the muscles.

But most deaths have occurred from inhaling small amounts over long periods. The leading sympton is anæmia, often quite unsuspected. Dr. Adelaide Smith reported in 1928 that in six New York factories one-third of the women showed definite symptoms of poisoning and another third probably did so.

In peacetime, benzene poisoning is commonest in the rubber industry.[1] In war it also occurs among explosive workers. The preventive measures include ventilation and the use of helmets with a good air supply, and the American Benzol Committee recommends medical inspection, including blood examination, of all workers once a month.

Almost all workers with nitro-glycerine suffer from its effects. On first exposure to its vapour—for example, in cordite drying rooms—there is a terrific headache, especially in warm weather. The same happens if a drop touches the skin. This passes off, and some girls who work with nitro-glycerine even say that it improves their complexions. But the headache comes on again if they knock off work for more than a few days.

Some people say that there are no chronic effects, but Dr. Laws, an American investigator, stated that in the long run the lungs and heart were generally affected,

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[1] See p. 225.

while the workers were very easily affected by alcohol, and also sexually over-excitable. However, I do not suppose that the Archbishops will take any steps to protect workers from nitro-glycerine, though this could be done by proper cleanliness and ventilation.

As in the case of trinitrotoluene, unless workers can change their clothes at the factory, they are liable to cause illness in their families and others with whom they come in contact by bringing home the substance on their clothes.

Most explosives other than trinitrotoluene and nitro-glycerine have little poisonous effect. When picric acid (trinitrophenol, lyddite) is absorbed by the skin it may cause a nasty skin disease, but it does not bring on general poisoning. But dinitrophenol, which was used in France in 1914–18, killed a great many French workers.

It was used in England in 1918, particularly for filling 12-inch shells, but the lessons of the French deaths had been learned, and only one man was killed. It is absorbed by the skin and given out again in the sweat, so that workers are stained yellow all over.

The first symptoms are fatigue and a feeling of tightness in the chest. These are followed by trembling, fever and frightful thirst. In severe cases the victims die in convulsions, gasping for breath.

In 1918 British workers with this substance were given, not merely overalls, but a complete set of underclothing, bath-rooms, and a separate cubicle for changing for each man. The urine was examined daily, and specially designed exhaust ventilation was installed to remove dust and fumes. Dust was removed from the edges of the

12-inch shells with a vacuum cleaner. It would be interesting to know what would happen to French workers who refused to work till these precautions were taken.

Such are some of the worst risks of poisoning in the manufacture of explosives and the filling of shells, bombs, mines and torpedoes. They can all be avoided if the workers insist on proper ventilation and cleanliness, and on safety measures, such as the provision of helmets with compressed air tubes, and proper medical examination of workers exposed to danger.

The fact that nothing is being printed on this subject in any daily newspaper except the *Daily Worker* makes it quite clear that our ruling class is not greatly interested in the safety of munition workers, who, if they are to preserve their life and health, will have to look after their own interests.

LEAD POISONING

A FAIR number of deaths and a great deal of ill health in industry are due to poisonous metals. In many long-established trades the workers are fairly well protected, but there is always danger when a new industry is started, or when, as a result of war, precautions are relaxed. So this question is a very big one to-day.

When I speak of poisonous metals, I must point out that, except for lead in the form of fine dust and mercury in the form of vapour, metals are not in themselves poisonous. But some of their compounds are. For example, you can swallow a good deal of mercury without harm, and mercurous chloride, or calomel, is a harmless purgative, but mercuric chloride, or corrosive sublimate, is a terrible poison.

The greatest killer among the poisonous metals is lead. Owing to preventive measures, only about 25 men die per year in Britain of officially recognised lead poisoning, as compared with much larger numbers in the past; but a great deal of the deaths from kidney and other diseases in trades using lead are certainly due to lead poisoning.

The British Government's attitude to lead poisoning was well illustrated by its refusal in 1926 to ratify the Geneva White Lead Convention forbidding the use of white lead for inside painting of buildings. Sir Thomas Legge, our chief authority on lead poisoning, resigned his post as Senior Medical Inspector of Factories as a protest, and later became Medical Adviser to the T.U.C.

Lead compounds are used in a great many industries. The heaviest casualties occur among house-painters who use white lead paints, but other trades which are dangerous from this cause include coach-painting, white lead manufacture, file-cutting, the making of accumulators, the pottery trade, paint manufacture, smelting, tinning, vitreous enamelling, printing, and the manufacture of lead tetraethyl for addition to petrol.

In most cases only some trades in an industry are dangerous. For example, type-founders are in far greater danger than compositors. And some bronzes contain no lead, whilst others, used for bearings, contain up to 20 per cent. For this reason, shop stewards should make every effort to find out whether the metals used in their shops contain lead.

The symptoms of lead poisoning are very various. Colic and constipation are common symptoms. The kidneys are often affected. But the worst effects are on the nervous system. "Dropped wrist," due to paralysis of the muscles whose contraction straightens the wrist and fingers, is very common.

When the brain is affected, the symptoms include convulsions, insanity, blindness, strokes of paralysis, and every kind of minor effect. Insanity was particularly common among American workers making lead tetraethyl. Finally, the reproductive organs are affected. Men become sterile and women have frequent miscarriages.

As a result, under the Women and Young Persons (Employment in Lead Processes) Act of 1920, women may not be employed in some processes such as mixing and pasting in the manufacture or repair of accumulators. And they may only be employed in processes involving the use of lead compounds subject to various precautions, including periodic medical inspection.

The main channel of poisoning is through the lungs, though a good many people have died from contaminated food, and lead tetraethyl can be absorbed through the skin. Thus the greatest danger in house-painting arises from scraping off old paint. And after the last war, there was a lot of lead poisoning among ship-breakers, due to the fumes produced from paint and lead stoppings by oxy-acetylene blowpipes.

This means that ventilation is one of the main weapons in the fight against lead poisoning, apart from the prohibition of the use of lead compounds. This ventilation includes, not only fresh air, but suction to remove fumes.

Cleanliness, and in particular thorough washing and removal of the clothes before eating, are also important.

Above all, attention must be paid to early signs of poisoning. These include a blue line on the gums, and changes in the blood which can be detected by a special microscopic examination. Dr. Sellers of Manchester wrote that "a blood test should be an essential part of the clinical examination of every worker exposed to lead."

And Dr. Lane used this method with such effect in an accumulator factory that he cut down the number of cases of lead poisoning from twenty-nine in two years to one in seven years. If you are exposed to lead poisoning, is your blood examined periodically? Or do you merely get a "once-over" from a doctor?

Unfortunately the blue line on the gums is not such an invariable sign as "punctate basophilia" of the blood cells. So Legge pointed out that "presence of a marked blue line on a workman will at once show that, not only he himself, but all his fellow workers in the particular process must be running grave risk from fumes or compounds of lead."

Lead poisoning is very difficult to cure, but, as the nervous symptoms resemble those of vitamin B_1 deficiency, the attempt was made to cure them with large doses of vitamin B_1 (also called "aneurin" or "thiamin"). This met with a certain degree of success.

It therefore seems that a diet containing plenty of this vitamin should form a part of the protection of lead workers. This could most readily be given through the works canteen, but, of course, rising prices will probably reduce the vitamin B_1 in lead workers' diets unless they themselves demand it.

Once more I would urge shop stewards and union officials to investigate conditions and try to improve them. For example, Legge thought, and I fully agree with him, that the precautions mentioned in the 1920 Act should be applied to men as well as women and children.

MORE POISONOUS METALS

BESIDES lead, a good many other metals used in industry are poisonous. Mercury is dangerous, not only when the metal or an amalgam is used, as in making thermometers and electric lamps and in water gilding, but in the hat trade, where rabbit fur is brushed with mercuric nitrate (a process called "carotting"), in some paint works, and in several branches of the chemical industry.

To-day two processes involving this danger are becoming important. One is the manufacture and use of mercury fulminate in explosive works. The other is the manufacture of surgical dressings soaked in cyanide or perchloride of mercury, where the dust given off in lapping is dangerous.

The metal may be inhaled as vapour, or rubbed through the skin, while the compounds may be swallowed as dust or with food. Fulminate of mercury also causes a special skin disease and inflammation of the eyes and nose. Mercury poisoning is seldom fatal, but causes a great deal of ill health.

The gums and mouth may be inflamed, and later on trembling of the face and hands comes on. The effect on the brain is extraordinary. Workers become anxious, shy and jumpy. "While affected with mercury poisoning," writes a worker, "I felt oppressed and uncomfortable, and was as shy as in my later boyhood days." Other symptoms include loss of appetite and wasting.

The main precautions are cleanliness and ventilation. Benches should have a smooth, sloping surface, so that mercury does not lie about. Local exhaust ventilation is essential. A proper mouth-wash is useful. Fulminate workers should not only beware of cracks in the skin, but dip their hands in 10 per cent. sodium hyposulphite solution several times daily. Periodic medical examination by a really competent doctor is of value.

Copper does not seem to be very poisonous, though it turns the teeth green. But brass-founders suffer from a very characteristic complaint called "brass-founders' ague." This is due to the zinc in the brass. Zinc workers rarely suffer from it, because zinc melts at a lower temperature than brass.

But brass has such a high melting-point that some of the zinc in molten brass is burned to zinc oxide which comes off as a white smoke. When this is breathed, it causes fever with shivering and a feeling of great cold, as in an attack of malaria. Workers become acclimatised, and often do not get another attack until they have taken a week or so off from work.

But because they do not get ague this does not mean that they are out of danger. On the contrary, they have enormous death rates from phthisis and other lung diseases.

In Chicago thirty years ago, only 15 per cent. of the brass-foundry workers were over forty years old, and only 1 per cent. over fifty years. And yet some writers who support capitalism object to the Druids' practice of human sacrifice.

The same symptoms are found when oxy-acetylene flames are used for cutting galvanised plates, and also among welders of manganese bronze containing much zinc. Other brass workers are decidedly unhealthy, but less so than founders. Protection is best given by ventilation rather than respirators.

In nickel manufacture, the metal is often combined with carbon monoxide to make nickel carbonyl, a liquid whose vapour is intensely poisonous. It is, in fact, so deadly that workers are now generally fairly well protected against it. However, they are in danger when cleaning out tubes which have contained the liquid or vapour, since it may remain in dust or dirt when the tubes are apparently clean.

Manganese compounds, such as the oxide and silicate, are poisonous when inhaled over long periods. There have been a number of cases among dock workers who handled the ores, and a few among smelters of iron ores containing much manganese.

The nervous system is specially affected, and the most sensitive part is the corpus striatum, in the middle of the brain, which is concerned in maintaining the normal tone in muscles at rest. Among the symptoms are a stolid, mask-like face, a monotonous voice, continual twitching and cramp, especially in the legs. Sometimes there is uncontrollable laughter and crying.

Life does not seem to be much shortened. On the other hand, no cure is known, and the victims are life-long cripples. The condition can be prevented by proper ventilation, both in handling the ores and in furnace work.

Finally, we have chromium. This metal is used for plating, and its compounds, such as chromic acid and potassium bichromate, are used in paint manufacture, in dyeing and calico printing, in tanning, in French polishing and in several branches of the chemical, china, glass and match industries.

The dust in a bichromate factory, or the mist given off from chromium-plating baths, has a peculiar effect on the septum of the nose, as the partition between the two nostrils is called. Legge found that this was ulcerated in three-quarters of chrome-platers. In about a sixth of the workers ten years ago there was actually a hole connecting the two nostrils.

Besides this, the skin of the hands is affected. The commonest sites are the knuckles and the skin round the nails, where "chrome holes" develop. In the early years of the industry, fingers often dropped off, but since 1920, when chrome ulceration became a notifiable disease, this has been rare. Sometimes the disease takes the form of eczema of the hands and face.

The Statutory Regulations of 1931 enjoin local exhaust ventilation to remove spray and other precautions. The 1918 Welfare Order enjoins rubber gloves for tanners who are "continually immersing their hands in chrome solutions." If they only do so from time to time, this is not compulsory.

"O sacred head, O desecrate,
O labour-wounded feet and hands,
O blood poured forth in pledge to fate
Of nameless lives in divers lands,
O slain and spent and sacrificed
People, the grey-grown speechless Christ"

wrote Swinburne. But the people is beginning to speak to-day and, what is more, to act.

DANGER IN THE RUBBER INDUSTRY

In an earlier article I referred to the danger of benzene vapour for rubber workers. In reply, I got a most interesting letter from C. I. Harrison of Manchester. He is a maker of waterproofs, and the next Annual Delegate Conference of the Waterproof Garment-Workers' Trade Union has a resolution before it which "calls for an investigation into the effect on the health of waterproof workers of the fumes which arise from the materials used in the manufacture of waterproof garments."

I recommend the Union officials to spend 7*s.* 6*d.* on the Industrial Health Research Board's Report for 1937 on "Toxicity of Industrial Organic Solvents." My correspondent mixed up benzene and benzine, and I'm sure I don't blame him. But benzene, or benzol, is a definite chemical substance of fixed composition, and benzine is a trade name for a mixture of mineral oil products. Eight French boot-makers were killed in 1932 because benzene was used instead of benzine.

What is worse, benzine is of different composition in different countries. The benzine made from Russian oil happens to be a good deal less poisonous than that made from American oil or German coal. My correspondent is probably working with what is called "light grade coal-tar solvent naphtha," a mixture of toluene, xylene and other substances.

A great number of liquids will dissolve rubber. Unfortunately, all the known solvents have a fairly low boiling-point, and therefore a fairly high vapour-pressure at ordinary temperatures. And all the vapours are probably somewhat poisonous, though some much more so than others.

In answer to Mr. Harrison's questions, I may say that the word "fumes" is used both for smoke consisting of particles and, as in this case, for vapour consisting of single molecules. All these vapours have some smell, but the smelliest are not always the most deadly.

One difficulty of writing is that the same substance may be used under many names. For example, trichlorethylene and mixtures containing it are sold under thirteen different names, such as Crawshawpol, Petazinol, Priol and Westrosol; but it can kill you under any of these names.

The first group of rubber solvents, including benzene, toluene, xylene, naphtha, benzine and cyclohexane, are all hydrocarbons—that is to say, compounds of carbon and hydrogen—and act mainly on the nervous system. Benzene vapour in large doses causes excitement, giddiness and other symptoms, like those of alcohol, leading up to convulsions and death.

Smaller amounts produce a variety of symptoms, of which headache, weakness, dizziness, vomiting and loss of appetite are the commonest. The blood is also usually affected, causing, not only anæmia, but bleeding from the nose, gums, womb and so on. Women are perhaps more susceptible than men, and pregnant women are certainly very liable to abortion, which often kills the mother as well as the baby. Poisoning by these substances is notifiable, and can be compensated under a Home Office Order of February 26th, 1918.

Certainly Mr. Harrison seems to have plenty to inhale. He writes: "A smell like gas clings to our clothes, so that, whenever we go in bus, train or home, people suspect leakages of gas pipes."

Another group of solvents are chlorine compounds, such as dichlorethylene, used for crêpe rubber soles, and tetrachlorethane, which massacred the aeroplane dope workers in the last war. These are narcotics like chloroform in strong doses, while in weak doses over long periods they may destroy the liver and kidneys.

Finally, carbon disulphide is a frightful poison which has made hundreds of workers into raving madmen. The official report on dangerous trades for 1906 mentions a factory where the windows of the vulcanising room were barred to stop men jumping out when they went mad. Precautions for its use are laid down in a Home Office Memorandum of 1935.

My correspondent says his boss has recently introduced overtime. In May, 1934, the Austrian Government fixed four hours per day as a maximum for workers in processes using benzene and several other solvents. This may be an exaggerated precaution, but certainly overtime is likely to be dangerous if there is enough solvent vapour to make a smell.

How should these dangers be met? In the first place, by ventilation. Not only should there be local suction to remove vapour, but also general ventilation. In an Edinburgh factory where two workers were killed in 1918, there were seventeen parts per 1,000 of benzene in an unventilated room, and only half a part per 1,000 when fans changed the air every two minutes.

Secondly, workers should be inspected, both for nervous and other symptoms and for changes in the blood, which can be seen when a drop is examined under the microscope. I should recommend the Waterproof Union to have such an examination done by a really competent specialist.

Finally, it should be possible to use less dangerous solvents. Probably any liquid which dissolves rubber will also damage the nervous system. For the same qualities which allow a liquid to take up rubber also make it soluble in certain greasy substances found in the brain. Nevertheless, some rubber solvents, such as tetrahydronaphthalene, or "tetralin," have so small a tendency to make vapour that they have not killed anyone so far.

Although water will not dissolve rubber any more than it will dissolve butter, yet the juice of the rubber plant is a milky fluid called "latex," in which tiny drops of rubber are suspended in water much as the microscopic drops of butter are suspended in milk. This is not a true solution, but a colloidal suspension such as I described in an earlier article.[1] Rubber is made from it as butter and

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[1] See p. 199.

cheese are made from milk. Its vapour is quite harmless.

In America, latex has largely replaced rubber dissolved in benzene for sealing cans. It could be used on a much larger scale in Britain. But such reforms are only likely when the workers really understand the chemistry of their jobs. Until this happens, the boss is very apt to say that safety measures are technically impossible.

The fluids of which I have written in this article are also used for other purposes—for example, in the paint, lacquer, linoleum and celluloid industries, for dry cleaning, degreasing and so on. In all these they constitute a danger. And they will go on doing so until the workers have the knowledge of chemistry and biology necessary to know what to do, and the control over industry needed to do it.