special class of questions and become experts in all that relates to fishery problems.

Further, is it desirable that the matters which are to be inquired into should be determined by an official unskilled in natural history? Or, on the other hand, that the selection of inquiries likely to lead to a satisfactory result should be made by a man of science, specially conversant with the nature of the things to be dealt with?

The organisation required consists, so far as persons are concerned, of:—

(1) A chief scientific authority.
(2) A staff of working naturalist-inspectors.
(3) A staff of clerks.

And, so far as material is concerned, of:—

(4) A London office, with collection of fishes, apparatus used in fishing, maps, survey-records, statistical returns, and library.
(5) A surveying-ship, under the orders of the Department, to be manned and maintained by the Admiralty.
(6) A chief laboratory fitted for carrying on investigations such as those named in Section II., and also two smaller movable laboratories, together with steam yacht fitted for dredging and sounding.
(7) Hatching-stations and fish-ponds.

With regard to the foregoing headings, it is a matter for consideration whether "the chief scientific authority" should be an individual or a committee of five. The position assigned to this post should be equal to that of the Director of the Geological Survey or the Director of the Royal Gardens, Kew, or, if the "authority" takes the form of a committee, it should be placed on the same footing as the Meteorological Council. The person or persons so appointed should be responsible for all the operations of the Department, and of such scientific training and capacity as to be likely to devise the most useful lines of inquiry and administration.

The "naturalist-inspectors" should be six in number, but operations might be commenced with a smaller staff. They should be thoroughly competent observers, and under the direction of the chief scientific authority they would be variously employed, either on the surveying-ship, at the chief laboratory, or in local laboratories, hatching-stations, or in the London office and museum.

The naturalists thus employed would become specialists in all matters relating to the life-history of fishes and their food; they would acquire a skill and knowledge far beyond that which it is possible to find amongst existing naturalists, who occasionally are requested to make hurried reports on such matters as salmon disease or the supposed injury of the herring-fisheries by trawlers.

One of the naturalist-inspectors should be a chemist and physicist, in order to report on the composition of the water and the nature of the bottom in the areas investigated.

"Clerks" would be required in the London office to tabulate statistics and carry on correspondence. These gentlemen need not necessarily have any scientific knowledge. It would probably be necessary to have a correspondent or agent of the Department in every large fishing centre. Probably the coast-guard officials might be taken into this service.

With regard to material equipment it appears to be necessary that a Scientific Fisheries Department should have at its London office a Museum of fishing apparatus for reference and instruction, and also complete collections illustrative of the fishes, their food, enemies, and other surroundings. In the same building would be exhibited maps showing the distribution and migrations of food-fishes, the coast temperature and its variations, the varying character of the sea-bottom, sea-water, &c.

The surveying-ship or ships would be provided by the Admiralty.

A central laboratory is in course of erection upon Plymouth Sound by the Marine Biological Association. Her Majesty's Government has promised to contribute 5000*l.* and 500*l.* a year to this institution, on condition that its resources are available for the purpose here indicated. Certain of the "naturalist-inspectors" (probably three at any one time) would be stationed at the Plymouth laboratory in order to carry on special studies of the development and food of particular species of fish.

The smaller movable laboratories, steam-yacht, and other appliances would not be costly.

ON NEW APPLICATIONS OF THE MECHANICAL PROPERTIES OF CORK TO THE ARTS[1]

IT would seem difficult to discover any new properties in a substance so familiar as cork, and yet it possesses qualities which distinguish it from all other solid or liquid bodies, namely, its power of altering its volume in a very marked degree in consequence of change of pressure. All liquids and solids are capable of cubical compression, or extension, but to a very small extent; thus water is reduced in volume by only 1/2000 part by the pressure of one atmosphere. Liquid carbonic acid yields to pressure much more than any other fluid, but still the rate is very small. Solid substances, with the exception of cork, offer equally obstinate resistance to change of bulk; even india-rubber, which most people would suppose capable of very considerable change of volume, we shall find is really very rigid.

I have here an apparatus for applying pressure by means of a lever. I place a piece of solid india-rubber under the plate and you see that I can compress it considerably by a very light pressure of my finger. I slip this same piece of india-rubber into a brass tube, which it fits closely, and now you see that I am unable to compress it by any force which I can bring to bear. I even hammer the lever with a mallet, and the blow falls as it would on a stone. The reason of this phenomenon is, that in the first place, with the india-rubber free, it spread out laterally while being compressed longitudinally, and consequently the volume was hardly altered at all; in the second case, the strong brass tube prevented all lateral extension, and because india-rubber is incapable of appreciable cubical compression, its length only could not be sensibly altered by pressure.

Extension, in like manner, does not alter the volume of india-rubber. In this glass tube is a piece of solid round rubber which nearly fills the bore. The lower end of the rubber is fixed in the bottom of the tube, and the upper end is connected by a fine cord to a small windlass, by turning which I can stretch the rubber. I fill the tube to the brim with water, and throw an image of it on to the screen. If stretching the rubber either increases or diminishes its volume, the water in the tube will either overflow or shrink in it. I now stretch the rubber to about 3 inches, or one-third of its original length, but you cannot see any appreciable movement in the water-level, hence the volume of the rubber has not changed.

Metals when subjected to pressures which exceed their elastic limits, so that they are permanently deformed, as in forging or wire-drawing, remain practically unchanged in volume per unit of weight.

I have here a pair of common scales. To the under sides of the pans I can hang the various specimens that I wish to examine; underneath these are small beakers of water which I can raise or lower by means of a rack and pinion. Substances immersed in water lose in weight by the weight of their own volume of water; hence if two substances of equal volume balance each other in air, they will also balance when immersed in water, but if their volumes are not the same, then the substance having the smaller volume will sink, because the weight of water it displaces is less than that displaced by the substance with the larger volume. To the scale on your left hand is suspended a short cylinder of ordinary iron, and to the right-hand scale a cylinder of ordinary copper. They balance exactly. I now raise the beakers and immerse the two cylinders in water; you see the copper cylinder sinks at once, and I know by that that copper has a smaller volume per pound than iron, or, as we should commonly say, it is heavier than iron. I now detach the copper cylinder, and in its place hang on this iron one, which is made of the same bar as its fellow cylinder, but forced, while red hot, into a mould by a pressure of sixty tons per square inch and allowed to cool under that pressure. The two cylinders balance, as you see. Has the volume of the iron in the compressed cylinder been altered by the rough treatment it has received? I raise the beakers, immerse the cylinders, the balance is not destroyed; hence we conclude that although the form has been changed the volume has remained the same. I substitute for the hot compressed cylinder one pressed into a mould while cold, and held there for some time, with a load of sixty tons per square inch; the balance is not destroyed by immersion, hence the volume has not been altered. I can repeat the experiments with these copper cylinders and the

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[1] A Paper read at the Royal Institution of Great Britain on April 9, 1886, by William Anderson, M.Inst.C.E., M.R.I.

result will be found the same. Extension also is incapable of appreciably altering the density of metals. I attach to the scales two specimens of iron taken from a bar which had been torn asunder by a steady pull. One specimen is cut from the portion where it had not been strained, and the other from the very point where it had been gradually drawn out and fractured. The specimens balance, I immerse them, you see the balance is not destroyed; hence the volume of the iron has not been changed appreciably by extension.

But cork behaves in a very different manner. I place this cylinder of cork into just such a brass tube as served to restrain the india-rubber and apply pressure to it in the same way; you see I can readily compress the cork, and when I release it it expands back to its original volume: the action is a little sluggish on account of the friction of the cork against the sides of the tube. In this case, therefore. a very great change in the volume of the material has been easily effected.

But although solids evidently do not change sensibly in bulk, after having been released from pressures high enough to distort them permanently, yet, while actually under pressure, the volumes may have been considerably altered. As far as I am aware, this point has not been determined experimentally for metals, but it is very easy to show that india-rubber does not change.

I have here some of this substance, which is so very slightly lighter than water, that, as you see, it only just floats in cold water but sinks in hot. If I could put it under considerable pressure while afloat in cold water, then, if its volume became sensibly less, it ought to sink. In the same way, if I load a piece of cork and a piece of wood so that they barely float, if their volumes alter they ought to sink.

In this strong upright glass tube I have, at the top, a piece of india-rubber, immediately below it a piece of wood, and below that a cork; the wood and the cork are loaded with metal sinkers to reduce their buoyancy. The tube is full of water and is connected to a force-pump by means of which I can impose a pressure of over 1000 lbs. per square inch. The image of the tube is now thrown on the screen and the pressure is being applied. You see at once the cork is beginning to shrink in all directions, and now its volume is so reduced that it is incapable of floating, and sinks down to the bottom of the tube. The india-rubber is absolutely unaffected, the wood does contract a little, but not sufficiently to be visible to you or to cause it to sink. I open a stop-cock and relieve the pressure; you see that the cork instantly expands, its buoyancy is restored, and it floats again. By alternately applying and taking off the pressure I can produce the familiar effect so well known in the toy called "the bottle imps." It is this singular property which gives to cork its value as a means of closing the mouths of bottles. Its elasticity has not only a very considerable range, but it is very persistent. Thus in the better kind of corks used in bottling champagne and other effervescing wines you are all familiar with the extent to which the corks expand the instant they escape from the bottles. I have measured this expansion, and find it to amount to an increase of volume of 75 per cent., even even after the corks have been kept in a state of compression in the bottles for ten years. If the cork be steeped in hot water, the volume continues to increase till it attains nearly three times that which it occupied in the neck of the bottle.

When cork is subjected to pressure, either in one direction, as in this lever press, or from every direction, as when immersed in water under pressure, a certain amount of permanent deformation or "permanent set" takes place very quickly. This property is common to all solid elastic substances when strained beyond their elastic limits, but with cork the limits are comparatively low. You have, no doubt, noticed in chemists' and other shops that, when a cork is too large to fit a bottle, the shopkeeper gives the cork a few sharp bites, or, if he be more refined, he uses a pair of specially-contrived pincers; in either case he squeezes the cork beyond its elastic limits, and so makes it permanently smaller. Besides the permanent set, there is a certain amount of what I venture to call sluggish elasticity, that is, cork on being released from pressure, springs back a certain amount at once, but the complete recovery takes an appreciable time.

While I have been speaking, a piece of fresh cork, loaded so as barely to float, has been inserted into the vertical glass pressure-tube. I apply a slight pressure, you see the cork sinks. I release the pressure, and it rises briskly enough. I now apply a much higher pressure for a moment or two, I release it, and the cork will either not rise at all, or will do so very slowly; its volume has been permanently altered; it has taken a permanent set.

In considering the properties of most substances, our search for the cause of these properties is baffled by our imperfect powers and the feeble instruments we possess for investigating molecular structure. With cork, happily, this is not the case; an examination of its structure is easy, and perfectly explains the cause of its peculiar and valuable properties.

All plants are built up of minute cells of various forms and dimensions. Their walls or sides are composed chiefly of a substance called cellulose, frequently associated with lignine, or woody matter, and with cork, which last is a nitrogenous substance found in many portions of plants, but is especially developed in the outer bark of exogenous trees, that is, trees belonging to an order, by far the most common in these latitudes, the stems of which grow by the addition of layers of fresh cellulose tissue outside the woody part and inside the bark. Between the bark and the wood is interposed a thin fibrous layer, which, in some trees, such as the lime, is very much developed, and supplies the bass matting with which all are familiar. The corky part of the bark, which is outside, is composed of closed cells exclusively, so built together that no connection of a tubular nature runs up and down the tree, although horizontal passages radiating towards the woody part of the tree are numerous. In the woody part of the tree, on the contrary, and in the inner bark, vertical passages or tubes exist, while a connection is kept up with the pith of the tree by means of medullary rays. In one species of tree, known as the cork oak, the corky part of the bark is very strongly developed. I project on the screen the magnified image of a horizontal section of the bark of the cork oak; you see nine or ten bands running parallel to each other: these are the layers of cellulose matter that have been deposited in successive years. I turn the specimen, and you now see the vertical section with the radiating passages clearly marked.

The difference between the arrangement of the cells or tissue forming the woody part of the tree and the bark is easily shown. I have here three metal sockets, supported over a shallow wooden tray. Into them are fitted, first, a cork cut out of the bark in a vertical direction, next, a cork cut in a radial direction, and, lastly, a piece of common yellow pine. By means of my force-pump, I apply a couple of atmospheres of hydraulic pressure. I project an image of the apparatus on the screen, and you see the water has made its way through the wood and through the cork cut in the radial direction, while the cork cut in the vertical direction is impervious.

The cork tree, a species of evergreen oak, is indigenous in Portugal and along both shores of the Mediterranean. The diagram on the wall has been painted from a sketch obligingly sent to me by Mr. C. A. Friend, the resident engineer of the Seville Waterworks, to whom I am also indebted for this branch of a cork tree, these acorns, this axe used in getting the cork, and for a description of the habits of the tree, its cultivation, and the mode of gathering the harvest.

The cork oak attains a height of 30 to 40 feet; it is not cultivated in any way, but grows like trees in a park. The first crop is not gathered till the tree is thirty years old, the next nine or ten years later; both these crops yield inferior cork, but at the third crop, gathered when the tree is fifty years old, the bark has attained full maturity, and after that will yield the highest quality of cork every nine or ten years. In the autumn of the year, when the bark is in a fit state, that is, for small trees, from three-quarters of an inch to one inch thick, and for larger ones up to one inch and a half, a horizontal cut is made, by means of a light axe like the one I hold in my hand, through the bark a few inches above the ground; succeeding cuts are made at distances of about a yard, up to the branches, and even along some of the large ones, then two or more vertical cuts, according to the size of the tree, and the bark is ripped off by inserting the wedge-shaped end of the axe-handle. In making the cuts great care is taken to avoid wounding the inner bark, upon the integrity of which the health of the tree depends; but where this precaution is taken, the gathering of the cork does not in any way injure the tree.

After stripping, the cork is immersed for about an hour in hot water, it is dressed with a kind of spokeshave, then laid out flat and weighted in order to take out the curvature; it is then stacked in the open air, without protection of any kind, for cork does not appear to be susceptible of receiving injury from the weather.

The minute structure of the bark is very remarkable. First, I project on the screen a microscopic section of the wood of the cork tree. It is taken in a horizontal plane, and I ask you to notice the diversity of the structure, and especially the presence of large tubes or pipes. I next exhibit a section taken in the same plane of the corky portion of the bark. You see the whole substance is made up of minute many-sided cells about 1/750 of an inch in diameter, and about twice as long, the long way of the cells being disposed radially to the trunk. The walls of the cells are extremely thin, and yet they are wonderfully impervious to liquids. Looked at by reflected light, if the specimen be turned, bands of silvery light alternate with bands of comparative darkness, showing that the cells are built on end to end in regular order. The vertical section next exhibited shows a cross section of the cells looking like a minute honeycomb. In some specimens large numbers of crystals are found. These could not be distinguished from the detached elementary spindle-shaped cells, of which woody fibre is made up, were it not for the powerful means of analysis we have in polarised light. I need hardly explain to an audience in this Institution that light passed through a Nicol prism becomes polarised, that is to say, the vibrations of the luminiferous ether are all reduced to vibrations in one plane, and, consequently, if a second prism be interposed and placed at right angles to the first, the light will be unable to get through; but if we introduce between the crossed Nicols a substance capable of turning the plane of vibration again, then a certain portion of the light will pass. I have now projected on the screen the feeble light emerging from the crossed Nicols. I introduce the microscopic preparation of cork cells between them, and you see the crystals glowing with many-coloured lights on a dark ground.

Minute though these crystals are, they are very numerous and hard, and it is partly to them that is due the extraordinary rapidity with which cork blunts the cutting instruments used in shaping it. Cork-cutters always have beside them a sharpening-stone, on which they are obliged to restore the edges of their knives after a very few cuts.

The cells of the cork are filled with gaseous matter, which is very easily extracted, and which has been analysed for me by Mr. G. H. Ogston, and proved to be common air. I have here a glass tube in which are some pieces of cork which have been cut into slices so as to facilitate the escape of the air. I connect the tube with an exhausted receiver and project the image on the screen; you see rising from the cork bubbles of air as numerous, but much more minute than the bubbles which rise from sparkling wines; much more minute, because the bubbles you see are expanded to seven or eight times their volume at atmospheric pressure on account of the vacuum existing in the tube. The air will continue to come off for an hour or more, and from measurements made by Mr. Ogston I find that the air occluded in the cork amounts to about 53 per cent. of its volume. The facility with which the air escapes, compared with the impermeability of cork to liquids is very remarkable.

I throw on the screen the image of a section cut from a cork which was kept under a vacuum of about 26 inches for five days and nights; aniline dye was then injected, and yet you see that the colour has not more than permeated the outermost fringe of cells—those, in fact, which had been broken open by the operation of cutting the cork. By keeping cork for a very long time in an almost perfect vacuum, and then injecting dye, a slight darkening of the general colour of a section of the cork may be noticed, but it is very slight indeed. How, then, does the air escape so readily when the cork is placed *in vacuo*?

The answer is, that gases possess the property of diffusion; that is, of passing through porous media of inconceivable fineness. When two gases, such as hydrogen and air, are separated by a porous medium, they immediately begin to pass into each other, and the lighter gas passes through more quickly than the heavier.

I have here a glass tube, the upper end of which is closed by a thin slice of cork, the lower end dips into a basin of water. Some hours ago the tube was filled with hydrogen, which you know is about 14½ times lighter than air; consequently, according to the law of diffusion, it will get out of the tube through the cork quicker than the air can get in by the same means, and the result must be that a partial vacuum will be formed in the tube, and a column of water will be drawn up. You see that such has been the case, and we have thus proved that the cells of cork are eminently pervious to gases. The pores in the cell-walls appear, however, to be too minute to permit the passage of liquids.

I closed the end of a glass tube 11 mm. diameter, with a disk of cork 1·75 mm. thick, cut at right angles to the axis of the tree; I placed a solution of blue litmus inside the tube, and suspended it in a weak solution of sulphuric acid. Had diffusion taken place, both liquids would have assumed a red colour, but after sixteen hours no change whatever could be detected. A like inertness was exhibited when the tube was filled with a solution of copper sulphate and suspended in a weak solution of ammonia; a deep blue colour would have appeared had any intermixture taken place, and the same tube is before you immersed in ammonia and filled with red litmus solution. It has been in this condition since February 28, but no diffusion has taken place. A disk of wood 6 mm. thick under the same circumstances showed, after a couple of hours, by the liquids turning blue, that diffusion was going on actively. It is this property of allowing gases to permeate while completely barring liquids that enables cork to be kept in compression under water or in contact with various liquids without the air-cells becoming water-logged, and that makes cork so admirable an article for waterproof wear, such as boot-soles and hats, for, unlike india rubber, it allows ventilation to go on while it keeps out the wet. The cell-walls are so strong, notwithstanding their extreme thinness, that they appear, when empty, to be able to resist the atmospheric pressure, for the volume of the cork does not sensibly diminish, even when all the air has been extracted. Viewed under very high power, cross-stays or struts of fibrous matter may be distinguished traversing the cells: these, no doubt, add to the strength and resistance of the structure.

From what you have seen you will have no difficulty in arriving at the conclusion that cork consists, practically, of an aggregation of minute air-vessels, having very thin, very water-tight, and very strong walls, and hence, if compressed, we may expect the resistance to compression to rise in a manner more like the resistance of gases than the resistance of an elastic solid such as a spring. In a spring the pressure increases in proportion to the distance to which the spring is compressed, but with gases the pressure increases in a much more rapid manner; that is, inversely as the volume which the gas is made to occupy. But from the permeability of cork to air, it is evident that, if subjected to pressure in one direction only, it will gradually part with its occluded air by effusion, that is by its passage through the porous walls of the cells in which it is contained. This fact can be readily demonstrated by the lever press which I have used, for, if the brass cylinder containing the cork be filled with soap and water and pressure be then applied, minute bubbles will be found to collect on the surface, and their formation will go on for many hours.

On the other hand, if cork be subjected to pressure from all sides, such as operates when it is immersed in water under pressure, then the cells are supported in all directions, the air in them is reduced in volume, and there is no tendency to escape in one direction more than another. An india-rubber bag, such as this, distended by air, bursts, as you see, if pressed between two surfaces, but if an india-rubber cell be placed in a glass tube and subjected to hydraulic pressure, it is merely shrivelled up; the strain on its walls is actually reduced.

To take advantage of the peculiar properties of cork in mechanical applications, it is necessary to determine accurately the law of its resistance to compression, and for this purpose I instituted a series of experiments of this kind. Into a strong iron vessel of 5½ gallons capacity I introduced a quantity of cork, and filled the interstices full of water, carefully getting out all the air. I then proceeded to pump in water, until definite pressures up to 1000 pounds per square inch had been reached, and, at every 100 pounds, the weight of water pumped in was determined. In this way, after many repetitions, I obtained the decrease of volume due to any given increase of pressure. The observations have been plotted into the form of a curve, which you see on the diagram on the wall. The base-line represents a cylinder containing one cubic foot of cork divided by the vertical lines into ten parts; the black horizontal lines according to the scale on the left hand represent the pressures in pounds per square inch which were necessary to compress the cork to the corresponding volume. Thus to reduce the volume to one-half, required a pressure of 250 pounds per square inch. At 1000 pounds per square inch the volume was reduced to 44 per cent.; the yielding then became very little, showing that the solid parts of the cells had nearly come together, and this corroborates Mr. Ogston's determination that the gaseous part of cork constitutes 53 per cent. of its bulk. The engineer, in dealing with a compressible substance, requires to know not only the pressure which a given change of volume produces, but also the work which has to be expended in producing the change of volume. The work is calculated by multiplying the decrease of volume by the mean pressure per unit of area which produced it. The ordinates of the dotted curve on the diagram with the corresponding scale of foot-pounds on the right-hand side are drawn equal to the work done in compressing a cubic foot of cork to the several volumes marked on the base-line. I have not been able to find an equation to the pressure curve; it seems to be quite irregular, and hence the only way of calculating the effects of any given change of volume is to measure the ordinates of the curve constructed by actual experiment. As may be supposed the pressures indicated by experiment are not nearly so regular and steady as corresponding experiments on a gas would be, and the actual form of the curves will depend on the quality of the cork experimented on.

The last point of importance in this inquiry relates to the permanence of elasticity in cork.

So far as preservation of elasticity during years of compression is concerned, we have the evidence of wine corks to show that a considerable range of elasticity is retained for a very long time. With respect to cork subjected to repeated compression and extension, I have very little evidence to offer beyond this, that cork which had been compressed and released in water many thousand times had not changed its molecular structure in the least, and had continued perfectly serviceable. Cork which has been kept under a pressure of three atmospheres for many weeks appears to have shrunk to from 80 to 85 per cent. of its original volume.

I will conclude this lecture by bringing under your notice two novel applications of cork to the arts.

Before the lecture-table stands a water-raising apparatus called a hydraulic ram. The structure of the machine is shown by a diagram on the wall. The ram consists of an inclined pipe, which leads the water from a reservoir into a chamber which terminates in a valve opening inwards. Branching up from the chamber is a passage leading to a valve, opening outwards and communicating with a regulating vessel, which is usually filled with air, but which I prefer to fill with cork and water. Immediately beyond the inner valve is inserted a delivery pipe, which is laid to the spot to which the water has to be pumped, in this case to the fountain jet in the middle of this pan.

The action of the ram is as follows:—The outer valve, which opens inwards, is, in the first instance, held open, and a flow of water is allowed to take place through it down the pipe and chamber. The valve is then released, and is instantly shut by the current of water which is thus suddenly stopped, and, in consequence, delivers a blow similar to that produced by the fall of a hammer on an anvil, and just as the hammer jumps back from the anvil, so does the water recoil back to a small extent along the pipe.

During this action, first, a certain portion of water is forced by virtue of the blow through the inner valve, opening outwards, into the cork vessel, and so to the delivery pipe, and instantly afterwards the recoil causes a partial vacuum to form in the body of the ram, and permits the atmospheric pressure to open the outer valve and re-establish a rush of water as soon as the recoil has expended itself. In the little ram before you, this action, which it has taken so long to describe, is repeated 140 times in a minute.

The ram is now working. You hear the regular pulses of the valve, and you see a jet of water rising some 10 feet into the air. I throw the electric light on the water, and I ask you to notice the regularity of the flow. You can, indeed, detect the pulses of the ram in the fountain, but that is because I am only using a regulating vessel of the same capacity as that generally used for air, and you will recollect that 44 per cent. of the substance of cork is solid and inelastic. By closing a cock I can cut off the cork vessel from the ram; you see the regularity of the jet has disappeared, it now goes in leaps and bounds. This demonstrates that the elasticity of cork is competent to regulate the flow of water. When air is used for this purpose the air-vessel has to be filled, and, with most kinds of water, the supply has to be kept up while the ram is working, because water under pressure absorbs air. For this purpose a "sniff-valve" is a necessary part of all rams. It is a minute valve opening inwards, placed just below the inner valve; at each recoil a small bubble of air is drawn in and passed into the air-vessel. This "sniff-valve" is a fruitful source of trouble. Its minuteness renders it liable to get stopped up by dirt; it must not, of course, be submerged, and, if too large, it seriously affects the duty performed by the ram. The use of cork gets rid of all these difficulties, no sniff-valve is needed, the ram will work deeply submerged, and there is no fear of the cork vessel ever getting empty. The duty which even the little ram before you has done is 65 per cent., and larger ones have reached 80 per cent.

The second novel application of cork is for the purpose of storing a portion of the energy of the recoil of cannon, for the purpose of expending it afterwards in running them out.

The result of the explosion of gunpowder in a gun is to drive the shot out in one direction, and to cause the gun to recoil with equal energy the opposite way. To restrain the motion of the gun "compressors" of various kinds are used, and in this country, for modern guns, they are generally hydraulic, that is to say, the force of recoil is expended in causing the gun to mount an inclined plane, and, at the same time, in driving a piston into a cylinder full of water, the latter being allowed to squeeze past the piston through apertures, the areas of which are either fixed or capable of being automatically varied as the gun recedes; or else the water is driven out of the cylinder through loaded valves. As a rule, the gun is moved out again into its firing position by its weight causing it to run down the inclined plane, up which it had previously recoiled. For naval purposes, however, this plan is inconvenient, because the gun will not run out to windward if the vessel is heeling over, on account of the inclined plane becoming more horizontal, or even inclined in the reverse direction, and should the ship take a permanent list, from a compartment getting full of water, the inconvenience might be very considerable.

In land service guns, when mounted in barbette, the rising of the gun exposes it and the loading detachment more to the enemy's fire, and in both cases, when placed in ports or embrasures, the ports must be higher than if the gun recoiled horizontally, and will therefore offer a better mark to the enemy's fire, especially that of machine guns, while the sudden rise of the gun in recoiling imposes a severe downward pressure on the deck or on the platform.

To obviate these disadvantages I have contrived the gun-carriage a model of which is before you on the table, and a diagram of which on the wall illustrates the internal construction. The gun is mounted on a carriage composed of two hydraulic cylinders, united so as to form one piece. The carriage slides on a pair of hollow ways, and also on to a pair of fixed rams, the rear ends of which are attached to the piece forming the rear of the mounting. There are water passages down the axes of the rams, and these communicate through an automatic recoil-valve, opening from the cylinders, with the two hollow slides. There is a second communication between the cylinders and slides by means of a cock, which can be opened or shut at pleasure. The hollow slides are packed full of cork and water, the latter also completely filling the cylinders, rams, and various connecting passages.

By means of a small force-pump enough water can be injected to give the cork so much initial compression as will suffice to run the gun out when the slides are inclined under any angle which may be found convenient.

When the gun is fired, the cylinders are driven on to the rams, and the water in the cylinders is forced through the hollow rams into the cork and water vessels formed by the slides, and the cork is compressed still farther. When the recoil is over, the automatic recoil-valve closes, and the gun remains in its rearward position ready for loading.

As soon as loaded, the running-out cock is opened, the expansion of the cork drives the water from around it into the cylinders, and so forces the gun out.

If it be desired to let the gun run out automatically immediately after recoil, it is only necessary to leave the running-out cock open, and then the water forced among the cork by recoil returns instantly to the cylinders, and runs the gun out quicker than the eye can follow the motion.

I will now load the model and fire a shot into this strong steel cylinder, at the bottom of which is a thick layer of soft wood. I will close the running-out valve, so that the gun shall remain in the recoiled position. Sir Frederick Abel has kindly arranged some of his electric fuses specially to fit this minute ordnance, and I can fire the gun by means of a small electro-magnetic battery. The gun has now recoiled, and remains in its rear position. I load again, open the running-out cock, the gun runs out, and I fire without closing the cock. You see the gun has recoiled and run out instantly again.

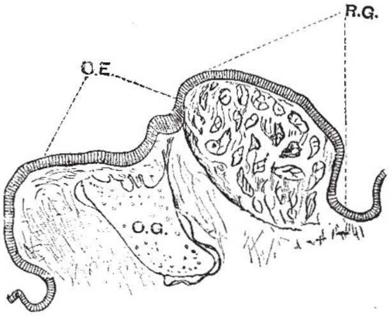
The arrangement I have adopted may be made by using air instead of cork, but air is a troublesome substance to deal with; it leaks out very easily, and without showing any signs of having done so, which might readily lead to serious consequences. A special pump is required to make up loss by leakage.

The merit of cork is its extreme simplicity and trustworthiness. By mixing a certain proportion of glycerine with the water it will not freeze in any ordinary cold weather.

NOTE ON THE RUDIMENTARY GILLS, ETC., OF THE COMMON LIMPET (PATELLA VULGATA)

SPENGEL, in his admirable paper "Die Geruchsorgane und das Nervensystem der Mollusken" (*Zeitschrift f. wiss. Zool.* xxxv.), figures a transverse section of one of the rudimentary gills and its surroundings. This appears to be incorrect in one or two particulars. In the first place the gill is figured as projecting freely at the surface. The examination of numerous sections has, however, convinced me that the epithelium is continued over the gill, being very high where continuous with the olfactory epithelium over the ganglion, but gradually getting lower, and passing into the ordinary epithelium, which lines the nuchal chamber. Consequently the rudimentary gill is *beneath* the surface, and moreover the sensory tract is partly extended over it, not being confined to the region immediately superjacent to the olfactory ganglion. Cunningham (*Q.J.M.S.*, xxii.), calls attention to the true relations of the gill, but gives no figure.

Spengel also represents the rudimentary gill as being full of large blood-sinuses, but carefully-prepared specimens show that these are in reality traversed by numerous fine strands of connective-tissue. The entire organ is made up of trabeculæ of connective-tissue, amongst which connective-tissue corpuscles abound. In some of the lacunæ masses of blood-corpuscles may be found.



Transverse Section of Rudimentary Gill, &c., of *Patella vulgata* (× 90). R.G. Rudimentary gill; O.E. olfactory epithelium; O.G. olfactory ganglion.

Several small nerves run from the olfactory ganglion to the olfactory epithelium, and in some specimens nerve-fibres can almost be traced into the sense-cells. Gibson ("Anatomy of *Patella vulgata*," *Trans. R.S.E.*, xxxii.) has been unable to detect an olfactory ganglion. This is, however, very evident in microscopic sections.

I have used the term "rudimentary gills," for there seems little doubt that the structures in question are, as Spengel advocates, of this nature, but, lying as they do beneath the surface, they can hardly be functional. This position, too, suggests that these organs must have been rudimentary for a very long time. As Patella (Palacmæa) occurs in the fossil state as far back as the Middle Cambrian (Sedg.), the pallial gills may have been developed for a considerable period.

If, as Spengel believes, the molluscan olfactory organ enables the animals of that group to perceive the quality of the water passing over the gills, it is difficult to understand its well-developed state in Patella, where its position would appear to prevent such a use. Hence the olfactory organ in this form probably has some other function—possibly it may have something to do with the locality-sense, though this is very improbable (see note by author on "The Habits of the Limpet," NATURE, vol. xxxi. p. 200). The preceding observations were made at the Scottish Marine Station. J. R. AINSWORTH DAVIS

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UNIVERSITY AND EDUCATIONAL INTELLIGENCE

CAMBRIDGE.—At the annual Scholarship election at St. John's College the following awards were made to students of Mathematics and Natural Science:—Hutchinson Studentship of 60*l.* a year for two years to A. C. Seward (First Class Nat. Sciences Tripos, Part II.), to enable him to follow up his researches in Fossil Botany; Hockin Prize for Physics with especial reference to Electricity, to Stroud (First Class Nat. Sciences Tripos, Part II.); Herschel Prize for Astronomy to Fletcher (Second Wrangler); Hughes Prizes for Mathematics to Fletcher, and for Natural Science to Rolleston (First Class Nat. Sciences Tripos, Part II.); Wright's Prizes for Mathematics to Baker and Orr, for Natural Science to Lake and Groom; Foundation Scholarships in Mathematics to Middlemast, Pressland, Tate, Bradford, Flux, and in Natural Science to Lake and W. Harris; extension of tenure of Scholarships to Kirby, Mossop, Bushe-Fox, and Baker in Mathematics, and to Shore and Turpin in Natural Science; Exhibitions in Mathematics to Hill, Fletcher, A. E. Foster, Norris, Varley, H. H. Harris, Orr, Greenidge, Flux, Card, Palmer, Millard, and in Natural Science to Lake, Groom, Rolleston, Seward, W. Harris; a Proper Sizarship in Natural Science to Cowell.

The following gentlemen have obtained first-class honours in the Natural Sciences Tripos, Part II., the subject for which they were specially classed being given after the name:—Carnegie, Chemistry, Caius; Edkins, Physiology, Caius; Hawkridge, Geology, Clare; Hudson, Physics, Pembroke; F. W. Oliver, Botany, Trinity; Rolleston, Human Anatomy with Physiology, St. John's; Seward, Geology, St. John's; Skinner, Chemistry, Christ's; Stroud, Physics, St. John's. Miss Freund, of Girton, was placed in the first class for Chemistry.

Messrs. Dixon, of Trinity College, and Fletcher, of St. John's, are respectively Senior and Second Wranglers. Both were educated at New Kingswood School, Bath, under Mr. T. G. Osborn. Miss Frost, of Newnham College, was placed between the 24th and 25th Wranglers.

In a recent discussion Prof. Stuart stated that 58 students attended the engineering courses and workshops in the Lent Term. Of these 32 were to be engineers; 7 were to engage in manufactures in which a knowledge of engineering was desirable; 3 were going into the army; 2 were to become teachers. As to their University position, 9 were M.A. or B.A., 21 were ready for the Mathematical Tripos, 2 for the Natural Sciences Tripos, 18 for the Special Examinations in Applied Science; 6 had only come to the University for a year's work in the workshops; 5 were not matriculated students.

DR. ORME MASSON, a graduate of Edinburgh University, and lately Elective Fellow in Chemistry, has been appointed to the Chair of Chemistry at Melbourne, Australia.

SCIENTIFIC SERIALS

Bulletins de la Société d'Anthropologie de Paris, tome ix., fasc. 1, 1886.—The present number gives the usual annual recapitulation of the rules of the Society, the lists of members, addresses by the outgoing and incoming presidents, financial and other reports, &c.—M. Moncelon laid before the Society a *résumé* of the principal results of his observations on the half-castes of New Caledonia during his residence in the colony. He drew attention to the evils resulting from the practice commonly followed by the native mothers of half-castes, of going back with their children to their native tribes, amongst whom these half-whites grow up in slavery as savages.—On certain Hova and Sakalava skulls, by M. Trucy. Both of these cranial groups are dolichocephalic, with an index of about 74, which is nearly the same as that of the Arabs of Algiers and the pariahs of Bengal. The Hovas and Sakalavas appear to be more intelligent than any other tribes of Madagascar, but while the Sakalava queen, the ally of France, submitted with her husband to be made the subject of careful anthropometrical observations, she enjoined upon the French officers to punish with death any one who opened or rifled a grave. It was consequently only by artifice and extreme circumspection that M. Trucy was able to obtain crania or other human bones. In the discussion which followed, regarding the mixed characters of the Hova crania, MM. Topinard, Dally, and others entered warmly into the question of typical and other distinctions of race.—On the development, in the adult, of supernumerary digits, by M. Fauvelle.