

grew for the space of six Days; after which they laid themselves up in their Bags. Thus they remain'd for two Days more without Motion, and then came forth in the Shape of Flies. (Fig. 5.) The Water at that time was all gone, and there remain'd no more of the Fruit than the Seeds, the Vessels which compos'd the Tunicks of the Ovarys, the outward Rind, and the Excrement of the Maggots; all which together weigh'd about an Ounce. So that there was lost of the first weight of the Fruit when it was cut, above twenty Ounces.

We may Judge from this, and other Cases of the like nature, how much Vegetable Life is dependent on Fermentation, and Animal Life on Putrifaction.

VII. *The Art of Living under Water: Or, a Discourse concerning the Means of furnishing Air at the Bottom of the Sea, in any ordinary Depths.*
By Edm. Halley, LL. D. Secretary to the Royal Society.

There have been many Methods propos'd, and Engines contriv'd, for enabling *Men* to abide a competent while under *Water*: And the Respiring fresh *Air* being found to be absolutely necessary to maintain Life in all that breath, several ways have been thought of, for carrying this *Pabulum Vitæ* down to the *Diver*, who must, without being somehow supplied therewith, return very soon, or perish.

We have heard of the *Divers* for Spunges in the *Archipelago*, helping themselves by carrying down *Spunges* dipt in Oyl in their Mouths: but considering how small a Quantity of *Air* can be suppos'd to be contained in
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the Pores or Interstices of a *Sponge*, and how much that little will be contracted by the Pressure of the *incumbent Water*, it cannot be believed that a Supply, by this means obtained, can long subsist a Diver. Since by Experiment it is found that a *Gallon of Air*, included in a *Bladder*, and by a Pipe reciprocally inspired and expired by the *Lungs* of a Man, will become unfit for any further Respiration, in little more than one Minute of Time; and though its Elasticity be but little altered, yet in passing the *Lungs*, it loses its *vivifying Spirit*, and is rendered effete, not unlike the *Medium* found in *Damps*, which is present Death to those that breath it; and which in an instant extinguishes the brightest *Flame*, or the shining of glowing *Coals* or red hot *Iron*, if put into it. I shall not go about to shew what it is the *Air* loses by being taken into the *Lungs*, or what it communicates to the *Blood* by the extream ramifications of the *Aspera Arteria*, so intimately interwoven with the *Capillary Blood-Vessels*; much less to explain how 'tis performed, since no discovery has yet been made, to prove that the ultimate Branches of the *Veins* and *Arteries* there, have any *Anastomoses* with those of the *Trachæa*; as by the *Microscope* they are found to have with one another. But I rather choose to leave this Enquiry to the Curious *Anatomist*, to whom the Structure of the *Lungs* is better understood; and shall only conclude from the aforesaid Experiment, that a naked Diver, without a *Sponge*, may not be above a couple of Minutes enclosed in Water, (as I once saw a *Florida-Indian* at *Bermudas*) nor much longer with a *Sponge*, without Suffocating; and not near so long without great Use and Practice: ordinary Persons generally beginning to stifle in about half a Minute of Time. Besides if the Depth be considerable, the pressure of the *Water* on the Vessels is found by Experience to make

the Eyes Blood-shot, and frequently to occasion spitting of Blood.

When therefore there has been occasion to continue long at the *Bottom*, some have contrived double flexible Pipes, to circulate *Air* down into a Cavity enclosing the *Diver* as with *Armour*, to bear off this pressure of the *Water*, and to give leave to his Breast to dilate upon *Inspiration*: the fresh *Air* being forced down by one of the Pipes with *Bellows* or otherwise, and returning by the other of them; not unlike to an *Artery* and *Vein*. This has indeed been found sufficient for small Depths, not exceeding twelve or fifteen Foot: but when the Depth surpasses three Fathoms, Experience teaches us that this Method becomes impracticable: for though the Pipes and the rest of the *Apparatus* may be contrived to perform their Office duly, yet the *Water*, its weight being now become considerable, does so closely embrace and clasp the Limbs that are bare, or covered with a flexible Covering, that it obstructs the Circulation of the *Blood* in them; and presses with so much force on all the Joints, where the *Armour* is made tight with *Leather*, *Skins* or such like, that if there be the least defect in any of them, the whole Engine will instantly fill with *Water*, which will rush in with so much violence, as to endanger the Life of the Man below, who may be drown'd before he can be drawn up. Upon both which accounts, the danger encreases with the Depth. Besides a Man thus shut up in a weighty *Case*, as this must needs be, cannot but be very unwieldy and unactive, and therefore unfit to execute what he is designed to do at the *Bottom*.

To remedy these Inconveniences, the *Diving-Bell* was next thought of; wherein the *Diver* is safely conveyed into any reasonable Depth, and may stay more or less time under *Water*, according as the *Bell* is of greater or lesser Capacity. This is most conveniently made in form

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of a *Truncate Cone*, the smaller *Basis* being closed, and the larger open: and ought to be so poized with *Lead*, and so suspended, that the Vessel may sink full of *Air*, with its greater or open *Basis* downwards, and as near as may be in a situation parallel to the *Horizon*, so as to close with the Surface of the Water all at once. Under this Couvercle the Diver setting, sinks down together with the included *Air* into the Depth desired; and if the Cavity of the Vessel may contain a Tun of *Water*, a single Man may remain therein at least an Hour, without much inconvenience, at five or six Fathoms Deep. But this included *Air*, as it descends lower, does contract it self according to the weight of the Water that compresses it; so as at thirty three Foot deep or thereabouts, the Bell will be half full of Water, the Pressure of it being then equal to that of the whole Atmosphere: and at all other Depths, the space occupied by the compressed *Air* in the upper part of the *Bell*, will be to the under part of its Capacity fill'd with Water, as thirty three Feet to the depth of the Surface of the Water in the Bell below the common Surface thereof. And this condensed *Air*, being taken in with the Breath, soon insinuates itself into all the Cavities of the Body, and has no sensible effect, if the Bell be permitted to descend so slowly as to allow time for that purpose. The only inconvenience that attends it, is found in the Ears, within which there are Cavities opening only outwards, and that by Pores so small as not to give admission even to the *Air* itself, unless they be dilated and distended by a considerable Force. Hence on the first descent of the Bell, a Pressure begins to be felt on each Ear, which by degrees grows painful, like as if a Quill were forcibly thrust into the Hole of the Ear; till at length, the force overcoming the Obstacle, that which constricts these Pores yields to the Pressure, and letting some condensed *Air* slip in, present Ease ensues.

But the Bell descending still lower, the Pain is renewed, and again eased after the same manner. On the contrary, when the Engine is drawn up again, the condensed Air finds a much easier Passage out of those Cavities, and even without Pain. This Force on the auditory Passages might possibly be suspected to be prejudicial to the Organs of Hearing, but that Experience teaches otherwise. But what is more inconvenient in this Engine, is the Water entering into it, so as to contract the bulk of Air (according to the aforesaid Rule) into so small a space, as that it soon heats and becomes unfit for Respiration, for which reason it must be often drawn up to recruit it: and besides the Diver being almost covered with the Water thus entering into his Receptacle, will not be long able to endure the Cold thereof.

Being engaged in an Affair that required the Skill of continuing under Water, I found it necessary to obviate these Difficulties which attend the use of the common Diving-Bell, by inventing some means to convey Air down to it, whilst below; whereby not only the Air included therein, would be refresh'd and recruited, but also the Water wholly driven out, in whatever Depth it was. This I effected by a Contrivance so easy, that it may be wondred it should not have been thought of sooner, and capable of furnishing Air at the bottom of the Sea in any quantity desired. The description of my *Apparatus*, take as follows.

The Bell I made use of was of Wood, containing about 60 Cubick Foot in its Concavity, and was of the form of a Truncate-Cone, whose Diameter at Top was three Foot, and at Bottom five. This I coated with Lead so heavy that it would sink empty, and I distributed the weight so about its bottom, that it would go down in a perpendicular Situation and no other. In the Top, I fixed a strong but clear Glass, as a Window to let in the
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Light from above; and likewise a Cock to let out the hot Air that had been Breathed; and below, about a Yard under the Bell, I placed a *Stage* which hung by three Ropes, each of which was charged with about one Hundred Weight, to keep it steady. This Machine I suspended from the Mast of a Ship, by a *Spritt* which was sufficiently secured by *Stays* to the Mast-head, and was directed by *Braces* to carry it over-board clear of the Ship-side, and to bring it again within-board as occasion required.

To supply Air to this Bell when under Water, I caused a couple of Barrels, of about 36 Gallons each, to be cased with Lead, so as to sink empty; each having a Bung-hole in its lowest Part to let in the Water, as the Air in them condensed on their descent: and to let it out again, when they were drawn up full from below. And to a Hole in the uppermost Part of these Barrels I fixed a Leathern Trunk or Hose, well liquored with Bees-Wax and Oyl, and long enough to fall below the Bung-hole, being kept down by a Weight appended; so that the Air in the upper Part of the Barrels could not escape, unless the lower ends of these Hose were first lifted up.

The Air-Barrels being thus prepared, I fitted them with Tackle proper to make them rise and fall alternately, after the manner of two Buckets in a Well; which was done with so much ease, that two Men, with less than half their Strength, could perform all the Labour required: and in their descent they were directed by Lines fastned to the under edge of the Bell, the which pass through Rings placed on both sides the Leathern *Hose* in each Barrel; so that sliding down by those Lines, they came readily to the Hand of a Man, who stood on the Stage on purpose to receive them, and to take up the ends of the *Hose* into the *Bell*. Through these *Hose*, as soon as their ends came above the Surface of the Water in the

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the Barrels, all the Air that was included in the upper Parts of them was blown with great force into the Bell, whilst the Water entred at the Bung-holes below, and fill'd them: and so soon as the Air of the one Barrel had been thus received; upon a signal given, That was drawn up, and at the same time the Other descended: and by an alternate Succession furnished Air so quick, and in so great Plenty, that I my self have been One of Five who have been together at the Bottom, in nine or ten Fathoms Water, for above an Hour and half at a time, without any sort of ill consequence: and I might have continued there as long as I pleased, for any thing that appeared to the contrary. Besides the whole Cavity of the Bell was kept entirely free from Water, so that I sat on a Bench, which was diametrically placed near the Bottom, wholly drest with all my Cloaths on. I only observed, that it was necessary to be let down gradually at first, as about 12 Foot at a time; and then to stop and drive out the Water that entred, by receiving three or four Barrels of fresh Air, before I descended further. But being arrived at the Depth designed, I then let out as much of the hot Air that had been Breathed, as each Barrel would replenish with Cool, by means of the Cock at the Top of the Bell; through whose Aperture, though very small, the Air would rush with so much violence, as to make the Surface of the Sea boyle, and to cover it with a white Foam, notwithstanding the great weight of Water over us.

Thus I found I could do any thing that was required to be done just under us; and that, by taking off the Stage, I could, for a space as wide as the Circuit of the Bell, lay the Bottom of the Sea so far Dry, as not to be over-shoes thereon. And by the Glass Window, so much Light was transmitted, that, when the Sea was clear, and especially when the Sun shone, I could see perfectly well to Write or Read, much more to fasten or lay hold on any thing

thing under us, that was to be taken up. And by the return of the Air-Barrels, I often sent up Orders, written with an Iron Pen on small Plates of Lead, directing how to move us from Place to Place as occasion required. At other times when the Water was troubled and thick, it would be dark as Night below; but in such Case, I have been able to keep a Candle burning in the Bell as long as I pleas'd, notwithstanding the great expence of Air requisite to maintain Flame

This I take to be an Invention applicable to various Uses; such as *Fishing for Pearl*, *Diving for Coral*, Spunges and the like, in far greater Depths than has hitherto been thought possible. Also for the fitting and plaining of the Foundations of Moles, Bridges, &c. upon Rocky Bottoms; and for the cleaning and scrubbing of Ships Bottoms when foul, in calm Weather at Sea. But as I have no experience of these matters, I leave them to those that please to try. I shall only intimate, that by an additional Contrivance, I have found it not impracticable for a Diver to go out of our Engine, to a good distance from it, the Air being conveyed to him with a continued Stream by small flexible Pipes; which Pipes may serve as a Clew to direct him back again, when he would return to the Bell. But of this perhaps more hereafter

VIII. *Observations on the Glands in the Human Spleen; and on a Fracture in the upper part of the Thigh-bone. By J. Douglass, M.D. and R. S. S.*

THAT Anatomy, as well as Physick and Surgery, has received much improvement from a careful and true observation of what was found in the Dissection of morbid