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A GUIDE FOR OCCUPANTS

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THE BODY

A GUIDE FOR OCCUPANTS

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To Lottie.
Welcome to you, too.

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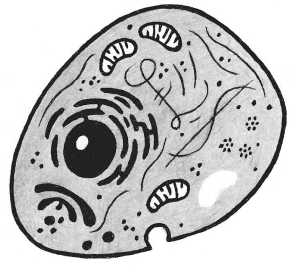
HOW TO BUILD A HUMAN



'How like a god!'

WILLIAM SHAKESPEARE,
Hamlet

Long ago, when I was a junior high school student in America, I remember being taught by a biology teacher that all the chemicals that make up a human body could be bought in a hardware store for $5 or something like that. I don't recall the actual sum. It may have been $2.97 or $13.50, but it was certainly very little even in 1960s money, and I remember being astounded at the thought that you could make a slouched and pimply thing such as me for practically nothing.

It was such a spectacularly humbling revelation that it has stayed with me all these years. The question is: was it true? Are we really worth so little?

Many authorities (for which possibly read 'science undergraduates who don't have a date on a Friday') have tried at various times, mostly

for purposes of amusement, to compute how much it would cost in materials to build a human. Perhaps the most respectable and comprehensive attempt of recent years was made by the Royal Society of Chemistry when, as part of the 2013 Cambridge Science Festival, it calculated how much it would cost to assemble all the elements necessary to build the actor Benedict Cumberbatch. (Cumberbatch was the guest director of the festival that year and was, conveniently, a typically-sized human.)

Altogether, according to RSC calculations, fifty-nine elements are needed to construct a human being. Six of these – carbon, oxygen, hydrogen, nitrogen, calcium and phosphorus – account for 99.1 per cent of what makes us, but much of the rest is a bit unexpected. Who would have thought that we would be incomplete without some molybdenum inside us, or vanadium, manganese, tin and copper? Our requirements for some of these, it must be said, are surpassingly modest and are measured in parts per million or even parts per billion. We need, for instance, just twenty atoms of cobalt and thirty of chromium for every 999,999,999½ atoms of everything else.

The biggest component in any human, filling 61 per cent of available space, is oxygen. It may seem a touch counterintuitive that we are almost two-thirds composed of an odourless gas. The reason we are not light and bouncy like a balloon is that the oxygen is mostly bound up with hydrogen (which accounts for another 10 per cent of you), to make water – and water, as you will know if you have ever tried to move a paddling pool or just walked around in really wet clothes, is surprisingly heavy. It is a little ironic that two of the lightest things in nature, oxygen and hydrogen, when combined form one of the heaviest, but that's nature for you. Oxygen and hydrogen are also two of the cheaper elements within you. All your oxygen will set you back just £8.90 and your hydrogen a little over £16 (assuming you are about the size of Benedict Cumberbatch). Your nitrogen (2.6 per cent of you) is better value still at just 27 pence for a body's worth. But after that it gets pretty expensive.

You need about thirty pounds of carbon and that will cost you £44,300, according to the Royal Society of Chemistry. (They were

using only the most purified forms of everything. The RSC would not make a human with cheap stuff.) Calcium, phosphorus and potassium, though needed in much smaller amounts, would between them set you back a further £47,000. Most of the rest is even more expensive per unit of volume, but fortunately only needed in microscopic amounts. Thorium costs almost £2,000 per gram but constitutes just 0.0000001 per cent of you, so you can buy a body's worth for 21 pence. All the tin you require can be yours for 4p, while zirconium and niobium will cost you just 2p apiece. The 0.000000007 per cent of you that is samarium isn't apparently worth charging for at all. It's logged in the RSC accounts as costing £0.00.

Of the fifty-nine elements found within us, twenty-four are traditionally known as 'essential elements', because we really cannot do without them. The rest are something of a mixed bag. Some are clearly beneficial, some may be beneficial but we are not sure in what ways yet, others are neither harmful nor beneficial but are just along for the ride as it were, and a few are just bad news altogether. Cadmium, for instance, is the twenty-third most common element in the body, constituting 0.1 per cent of your bulk, but it is seriously toxic. We have it in us not because our body craves it, but because it gets into plants from the soil and then into us when we eat the plants. If you live in North America, you probably ingest about eighty micrograms of cadmium a day, and no part of it does you any good at all.

A surprising amount of what goes on at this elemental level is still being worked out. Pluck almost any cell from your body and it will have a million or more selenium atoms in it, yet until recently nobody had any idea what they were there for. We now know that selenium makes two vital enzymes, deficiency in which has been linked to hypertension, arthritis, anaemia, some cancers, and even, possibly, reduced sperm counts. So, clearly it is a good idea to get some selenium inside you (it is found particularly in nuts, wholemeal bread and fish), but at the same time if you take in too much you can irremediably poison your liver. As with so much in life, getting the balances right is a delicate business.

Altogether, according to the RSC, the full cost of building a new

human being, using the obliging Benedict Cumberbatch as a template, would be a very precise £96,546.79. Labour and VAT would, of course, boost costs further. You would probably be lucky to get a take-home Benedict Cumberbatch for much under £200,000 – not a massive fortune, all things considered, but clearly not the meagre few dollars that my junior high school teacher suggested. That said, in 2012 *Nova*, the long-running science programme on the TV network PBS in America, did an exactly equivalent analysis for an episode called 'Hunting the Elements' and came up with a figure of $168 for the value of the fundamental components within the human body, illustrating a point that will become inescapable as this book goes on, namely that where the human body is concerned the details are often surprisingly uncertain.

But of course it hardly really matters. No matter what you pay, or how carefully you assemble the materials, you are not going to create a human being. You could call together all the brainiest people who are alive now or have ever lived and endow them with the complete sum of human knowledge, and they could not between them make a single living cell, never mind a replicant Benedict Cumberbatch.

That is unquestionably the most astounding thing about us – that we are just a collection of inert components, the same stuff you would find in a pile of dirt. I've said it before in another book, but I believe it's worth repeating: the only thing special about the elements that make you is that they make you. That is the miracle of life.

We pass our existence within this warm wobble of flesh and yet take it almost entirely for granted. How many among us know even roughly where the spleen is or what it does? Or the difference between tendons and ligaments? Or what our lymph nodes are up to? How many times a day do you suppose you blink? Five hundred? A thousand? You've no idea, of course. Well, you blink fourteen thousand times a day – so many that your eyes are shut for twenty-three minutes of every waking day. Yet you never have to think about it, because every second of every day your body undertakes a literally unquantifiable number of tasks – a quadrillion, a nonillion, a quindecillion, a

vigintillion (these are actual measures); at all events some number vastly beyond imagining – without requiring an instant of your attention.

In the second or so since you started this sentence, your body has made a million red blood cells. They are already speeding around you, coursing through your veins, keeping you alive. Each of those red blood cells will rattle around you about 150,000 times, repeatedly delivering oxygen to your cells, and then, battered and useless, will present itself to other cells to be quietly killed off for the greater good of you.

Altogether it takes seven billion billion billion (that's 7,000,000,000,000,000,000,000,000,000, or seven octillion) atoms to make you. No one can say why those seven billion billion billion atoms have such an urgent desire to be you. They are mindless particles, after all, without a single thought or notion between them. Yet somehow for the length of your existence, they will build and maintain all the countless systems and structures necessary to keep you humming, to make you you, to give you form and shape and let you enjoy the rare and supremely agreeable condition known as life.

That's a much bigger job than you realize. Unpacked, you are positively enormous. Your lungs, smoothed out, would cover a tennis court, and the airways within them would stretch from London to Moscow. The length of all your blood vessels would take you two and a half times around the Earth. The most remarkable part of all is your DNA. You have a metre of it packed into every cell, and so many cells that if you formed all the DNA in your body into a single fine strand it would stretch ten billion miles, to beyond Pluto. Think of it: there is enough of you to leave the solar system. You are in the most literal sense cosmic.

But your atoms are just building blocks, and are not themselves alive. Where life begins precisely is not so easy to say. The basic unit of life is the cell – everyone is agreed on that. The cell is full of busy things – ribosomes and proteins, DNA, RNA, mitochondria and much other microscopic arcana – but none of those are themselves alive. The cell itself is just a compartment – a kind of little room: a