MEDICAL PRACTICE

Contemporary Themes

De motu urbanorum

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Three years ago I decided to do my rounds as a general practitioner in central London on a bicycle. I needed to be able to move freely in heavy traffic and it was clear that the parking problem would solve itself if I had nothing large to park. The benefits have been immense and predictable, and, as the 20th century slides uneasily into its last quarter, restless with over-population, pollution, and diminishing resources, this seems an appropriate moment to compare the two types of private transport available to us on the roads of cities.

Energy Consumption

Our patients, the long-suffering and generally under-exercised British public, continue to show such massive unawareness of the many advantages of the bicycle that it becomes indeed a therapeutic duty to contrast for them this clean, quick, quiet, and civilized machine with that oxygen-eating, air-defiling dissipator of energy—my faithful motor car. I say faithful because anything less would be churlish, and it is with real reluctance that I expose to public gaze the imperfections of a family friend. But already the clouds are gathering round the internal combustion engine as we have used it, and we are being forced to consider less wasteful ways of getting ourselves about. For a car uses only 20% of the combustible energy of its fuel in moving forward: 4% goes to essentials such as transmission, dynamo, fan, and water pump,¹ but over 75% is lost as heat—40% through the exhaust and most of the remaining 35% by conduction and convection through something misleadingly called a radiator (the one thing it does hardly at all). The cyclist is altogether more temperate. Indeed from the standpoint of physics he is not a heat engine at all, but a constant-temperature energy converter more analogous to a fuel cell²; and his contribution to the increasing entropy of our solar

system is commendably small. His expenditure of energy in terms of his car's use of petrol is the equivalent of 1500 miles to the gallon (536 km/l), and, which puts him even more on the side of the angels, he leaves the air cleaner than he finds it, thanks to the trapping of inspired particulate debris by the mucous sheet covering his bronchial and bronchiolar epithelium.

THE CONSTANT TEMPERATURE ENERGY CONVERTER ON KING'S ROAD

Some time ago, with the help of Dr. F. J. Prime of the Brompton Hospital, I arrived at figures for gas exchange when cycling² that depended on my equating correctly the feel of my effort on the road with the resistance applied to the bicycle ergometer in his laboratory. This method established satisfactorily the orders of comparison with my car that I was seeking, but it involved a guess on my part which would have made every scientific observer from Eratosthenes to Rutherford recoil in dismay. I felt I had to go further, and the obvious place to begin was the borough engineer's drawing office. There I was made most welcome and within minutes was being shown the measured mile down the King's Road. They evidently assumed that even a man on a bicycle wearing nose clips and breathing through a one-way valve into a Koffranyi-Michaelis spirometer would raise no eyebrows there—and how right they were.

At the time of the experiment the air of Chelsea was almost at its best. The unending crawl of fuming cars had lessened temporarily, and a light north-easterly breeze was blowing the much improved smoke from the Lot's Road power station in the other direction for once. The spirometer had been kindly lent to me by Dr. Griffith Pugh, and it seemed almost indecent to be using this particular machine in safety and comfort over smooth ground 25 feet (7.6 m) above mean sea level when in 1953 it had measured at 23 000 feet (7010 m) the far higher ventilation rates of men working to their limit on the Lhotse face during the first successful ascent of Everest. Nevertheless, it uncomplainingly measured me, at 158 litres of expired air per mile (98.7 l/km). This was 11% less than my 178 litres on the laboratory ergometer at an estimated 15 m.p.h. (24 k.p.h.) work load, and indicated that the true difference in oxygen consumption per unit distance at steady speed between a 2 litre car at 30 m.p.h. (48.3 k.p.h.) and me on my bicycle at 16 m.p.h. (25.8 k.p.h.)—as it proved to be—was nearer 60:1 than the 50:1 ratio which the earlier figures suggested. And I breathe out no hydrocarbons, no nitrogen oxides, virtually no

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carbon monoxide, and no lead. In practice, of course, 16 m.p.h. (25.8 k.p.h.) is a distinctly sluggish speed for a bicycle in good shape and I was able to keep mine down to it only by unwavering concentration and self control.

Economy

In the past three years I have travelled 6000 (9660 km) miles on my bicycle which otherwise I should have done in my car—an average of eight miles (12.9 km) per working day. The saving in time has been more hours than I can count, in petrol more than 240 gallons (1090 litres), and to the atmosphere about 2 000 000 litres of oxygen, 1 300 000 litres of carbon dioxide, and 300 000 litres of carbon monoxide, at normal temperature and pressure. Now 2 000 000 litres of oxygen sounds a lot but you may well say, "Why the fuss? The earth is large and its atmosphere miles deep; 2 000 000 litres is only 70 600 cubic feet (1977 m³), of pure oxygen which is not much more than twice the capacity of the Long Room at Lords (32 400 cubic feet (908 m³)). All you have saved in three years' cycling is the oxygen content of the air of 11 Long Rooms." And you would be right. But these gas volumes derive from the very modest mileage of a single motor car. Compounded for a city the amounts are more disturbing. At continental levels they require at least some thought.

Byproducts of Combustion

Professors Angrist and Hepler of the Carnegie Institute of Technology in their book "*Order and Chaos*" a marvellously readable and amusing account of the laws of thermodynamics and their applications to life, discuss as an example the amount of petrol burned by all the vehicles in the United States in 1962. It was 59.3 thousand million U.S. gallons or 190 million tons (1 U.S. gallon = 0.83 imperial gallon), and, "If we were to fill Africa's Zambesi River with this quantity of gasoline, it would take nearly two days (at 25 million gallons per minute) to dump it over Victoria Falls." Its ignition, it can be calculated, consumed about 5×10^{11} litres—700 million tons—of oxygen and produced 630 million tons of carbon dioxide and 100 million tons of carbon monoxide. This lethal gas with its remarkable affinity for animal respiratory pigment is believed to be oxidised in the upper layers of the atmosphere to yet further carbon dioxide and is slightly lighter than air, which would appear to be something of a mercy. The same cannot unfortunately be said of that other odious atmospheric layabout called lead, which is pumped into large cities daily by the ton and accumulates if not blown away. The car is the culprit. The well-maintained diesel is blameless in these respects; London's buses emit negligible amounts of carbon monoxide and no lead.³

CARBON DIOXIDE

Surprisingly, the concentration of oxygen in the atmosphere seems to be holding up, and for this we must thank our terrestrial and, more particularly, our marine flora. But something does seem to be happening to carbon dioxide. Professor Lamb, director of the Climatic Research Unit in the University of East Anglia at Norwich, has stated that compared with its level in 1900 the carbon dioxide content of atmosphere is believed to have increased 5% by 1944, and 10% by 1967⁴; and in view of our carefree profligacy with natural resources of all kinds we should perhaps think a little about what is after all a considerable and rapid proportional change in one chemical component of our environment.

Mr. Peter Wright of the same unit tells me that this increase in carbon dioxide is most probably to be ascribed to the greater burning of fossil fuels, and that as the carbon dioxide in the atmosphere is known to absorb some of the long wavelength (12-18 μ m) infrared radiation emitted by the earth and reradiate a portion of it back down—while having little effect on incoming solar radiation—there are sound theoretical reasons for expecting increased carbon dioxide to result in warmer climates. On the other hand, the temperature of the earth's surface appears to be falling, and it has even been suggested that we may be heading for another ice age, in which still hypothetical event we might be spared the climatic cooking that we deserve from our headlong exploitation of the earth's hydrocarbon fuel reserves. What our great grandchildren will say about us is more predictable, and that could be scorching. We must just hope that our atmosphere continues to keep cool for if the polar ice caps melt the North Sea

risks and with it the Wash; and though some people might not for a time lose too much sleep over that the sequel is shattering—an appallingly final disaster: the sinking of Ely and Cambridge in vast undrainable fens.

More Personal Concerns

But important though these elemental and even cataclysmic considerations may be, there are questions of more immediate concern at the personal level: the problem, for instance, of temperature regulation when examining the patient after a fast ride. A perspiring doctor can be misunderstood. The trouble is that like my car I am air cooled, and with an efficiency that my car cannot match. I exchange mainly latent heat by a biological mechanism of such transparent elegance and economy of space that no piece of engineering however subtle can hold a candle to it. In short, I evaporate. Yet a doctor pedalling post-haste—no irony intended—on the straight path of duty can still move in the most sophisticated circles, though, as one senior London cycling surgeon points out, it is important to remember to remove one's trouser clips as these detract from the dignity of the consultation. This same surgeon relates "the occasional great pleasure when called to a hotel such as Claridges of handing one's steed to the magnificent gentleman with a polite request to mind it. One splendid chap remarked 'I'll just walk her up and down a bit until she stops sweating Sir.'"

The satisfaction of overtaking Jaguars and Aston Martins continues, though constant repetition has dulled the edge of that particular pleasure; but it would be idle to pretend that it is not extremely good for morale. Are there then no humiliations? Well, yes, I have had one. I have been left behind in Hyde Park by another bicycle. It happened soon after I had had to renew my rear tyre, which, at 1600 miles (2580 km), was down to the canvas. The shearing forces on this tyre when I accelerate are, of course, immense. Above it is a 16½ lb (9.9 kg) case, and with me in the saddle the compression force on the tread in contact with the road is 38 lb/in² (2.7 kg/cm²)—nearly three times that on the front wheel, double that on the tyres of my car, and equal to the pressure on a diver grubbing for North Sea gas in 87 feet (26.5 m) of water. The truth in fact is all too clear: in cycling terms I am not an express. All I can ever be is fast mixed goods.

WHITE TIE AND TAILS

This is not to imply, however, that my bicycle is a mere workhorse, unfitted for the more exalted echelons of London's social life. It is, for example, ideally suited to the dinner jacket as I have discovered. But supposing instead of a black tie you have to appear in a white one. What then do you do with your tails? Hardly a question for well-organised human primates, one would have thought, yet I was faced with this very dilemma only recently when for the first time in nearly 20 years I had put on this splendidly formal, yet curiously atavistic—not to say tribal—attire. Our early 19th century forebears on their horses had no difficulty because the ends of their tail coats could be hitched up to the buttons at the back of the jacket by button-holes. These, however, disappeared as the tails of Victorian day and evening dress grew longer and more foppish, but, providentially, the paired back buttons have remained, and from these can be slung by a short piece of string a large bulldog clip which holds the otherwise undisciplined tail-ends well clear of the oil on the rear brake calipers.

The occasion for this deft sartorial adjustment was a City banquet of near gothic magnificence at the Vintners' Hall. The Vintners do indeed trace back their origins to the 14th century, almost to Early English times, and true to style they invited us to arrive decorated. They also undoubtedly expected us to emerge perpendicular, and at the risk of labouring the obvious it has to be said that here again the cyclist has it over the motorist. The direr penalties of the law weigh not on him, and he has only to reach—and stay on—his bicycle for the rush of cold air past his face to see him safely home; which, I am happy to say, it did for me.

Efficiency

The *Scientific American* of March 1973 carried a fascinating article on bicycle technology by S. S. Wilson.⁵ In it he produced a graph which showed that a man on a bicycle is more efficient than any other animal or machine in terms of energy consumed per unit body weight per unit distance. He uses only one-fifth of the energy of a man walking and at 0.15 calories (0.63 J) per gram per kilometre he handsomely

outdoes even the salmon, which otherwise leads the field—from, inter alia, horses, jet-airliners, motor cars, pigeons, dogs, humming birds, and bees in that order.

For me on my bicycle this figure converts to 19 300 calories per mile, or, in nutritional parlance, 19.3 calories (0.0504 MJ/km), for it has to be remembered that the "calories" of the dietitian are the kilocalories of the scientist. This means that a glass of milk—130 kilocalories (0.54 MJ)—will take me on my bicycle for over six miles (9.7 km), a large slice of bread for five miles, and a fair-sized apple or boiled egg for four. A lump of refined sugar will carry me less than one. A 2-oz (56-g) bar of milk chocolate, by contrast, contains 300 kilocalories (1.24 MJ), and so do 1½ pints (1.05 l) of draught bitter; but try giving that to a Rolls Royce and see how far you get. Even if it were able to make use of energy in such a wholesome and unexplosive form that magnificent machine would be lucky to lurch 200 yards (180 m), whereas the cyclist on this fuel can travel 15 miles (24 km). One final fact perhaps deserves recording: caviar is weight for weight a marginally more powerful fuel than unenriched muffins. But if you are a working doctor or a working anything else and need your calories quickly go for the muffins.

Evolution

And what of the future, for us whose physiology is still—as it always was—more fitted to the austerities of the stone age than the enticements of affluence? It does not take much imagination to discern a fork in our evolutionary path. Our descendants will look back on a time of some difficulty for *Homo sapiens*—as he had hopefully and with some reason called himself. An originally

privileged subgroup of the species failed to readapt. They came to believe that they could not move any distance unless they were carried, either by their cars or by some other propulsive aid. They ceased to do any significant muscular work, and by one of those strange twists of history they became in the end the prisoners of the machines which were to have set them free. The phenomenon was seen in all races and in some more than others. Only isolated communities in rough terrain escaped. This pitiable creature was known at first as *Homo vehiculo constrictus*, but as it rapidly became apparent that he was constricted not only in his freedom of movement but also in his world view and his arteries he came to be called simply *Homo constrictus*. The writing was on the wall and by the end of the holocene he was gone. All future races of mankind descended from the other more active subgroup—*Homo se propellens*. This very advanced human primate was clever, keen, and cultured. His archetype in many societies was the cross-country runner. He walked or went on a bicycle, and he survived.

References

- ¹ Angrist, S. W., and Hepler, L. G., *Order and Chaos. Laws of Energy and Entropy*. New York, Basic Books Inc., 1967.
- ² Williams, R. E., *Lancet*, 1973, 1, 596.
- ³ Lawther, P. J., personal communication.
- ⁴ Lamb, H. H., *Climate Present, Past and Future*. Vol. I. London, Methuen, 1972.
- ⁵ Wilson, S. S., *Scientific American*, 1973, 228, No. 3, p. 81.

Outside Europe

Should undergraduate medical training in a developing country be different?

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It is claimed^{1,2} that the type of doctor needed in a developing country is different from that required in a developed country and that those trained in medical schools which base their curriculum on that in Britain are unsuitable for manning the health services of these developing countries. Whether the product of a medical school is considered satisfactory or not depends on at least three factors: (a) the basic raw material selected for training which, if bad, will result in an unsatisfactory end product; (b) the instruction given, its content, and relevance to the disease problems of the country; and (c) the work a doctor is called on to perform.

The curriculum, whether it is British based or not, is, therefore, only one of several possible reasons for "unsatis-

factory" doctors, and if Sri Lanka and other developing countries are to get value for the considerable investment they make in the training of doctors,³ all these factors must be considered.

Basic raw material: Defects in selection

Lack of interest in medicine—This is not a problem confined to the developing countries.⁴ Students embark on a medical career for a variety of reasons such as an interest in medicine, an assured job, a comfortable income, prestige and, possibly, the drama of medicine. It is doubtful whether more than half of those chosen are really interested in the care of sick people. The lack of interest is undoubtedly due to the way a student is selected—that is, entirely on his ability to pass an examination with no assessment as to his suitability for that particular career. Such methods of assessment as an interview or a school principals report, despite their known limitations, do offer some opportunity for judging the suitability of a student. An early opportunity for such assessment might arise in medical school if students were exposed to the care of patients in the first two years. This would also give the students an early opportunity of deciding whether to pursue this particular career. A decision is more easily taken at this stage to divert someone to a paramedical field rather than allow an unsuitable student to continue in medicine.

Wrong sex ratio—Because of the lack of suitable living quarters and the remoteness of some of the smaller hospitals there is a marked reluctance of women to staff these hospitals. Despite this the percentage

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