HOW MANY POUNDS OF OXYGEN DO WE "EAT" EACH DAY?

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As teachers we feel the need to do more than merely teach basic facts and concepts. We want to make the subject matter more relevant; we would like to help integrate the various threads of the students' education and life experiences; and, finally, we wish to increase the students' interest and involvement in the learning process. There is the temptation, however, when thinking along these lines, to consider the use of time-consuming, complex methods of approach. These might involve slide presentations, videos, special lectures, special assignments, student reports, etc. The very complexity of these approaches often reduces their effectiveness. Moreover, the time and effort required often keeps us from attempting them more than once or twice. Are simpler and more effective approaches to enrichment possible? Reflecting on our own education, many of us may recall the disproportionate impact of some revealing aside thrown by a teacher unexpectedly into an otherwise mundane lecture or discussion: perhaps a short, penetrating observation providing an unexpected perspective on what was being discussed, a bolt of lightening that briefly illuminated the dim landscape of the classroom. This we may remember when much from the course has been totally forgotten. These jewels of thought—epiphanies—can be shared by teachers to enrich, enlighten, and refresh their students and each other. The jewels we speak of need not be precious or rare. Indeed, the metaphors "a bolt of lightening" and "jewels" may mislead by their intensity and drama. Is it not in the often unexamined, simple, and humble all around us that wisdom can be found? The following is an example.

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As everyone knows, the energy that is needed by the human body to run its affairs is derived from "food"—material ingested via the mouth and processed along the gastrointestinal tract. Alas, this elementary idea is somewhat misleading. After the food is digested and absorbed, it must be combined with oxygen if its energy is to be fully extracted. Thus, in the absence of oxygen, only 5% of the food's energy stores can be extracted by the body's cells, an amount insufficient for life. Deprived of oxygen we quickly die.

Clearly, the chemical substance oxygen is as much food for us as is any meat or vegetable. On the earth's surface, this precious substance surrounds us. It is continuously available, whereas food is not; that is why we tend to take oxygen, but not food, for granted. If we lived in a place where there was no oxygen in the immediate environment, we would have to shop for oxygen as we do for other food items. In such a place automobiles would have two tanks, one for oxygen, the other for gasoline.

The oxygen in our atmosphere is a gas, something very light. We hardly perceive it unless a wind is blowing. This leads us to believe that the oxygen we ingest is of negligible mass. Is this true? How many pounds of oxygen do we, in fact, consume for every pound (by dry weight) of solid food ingested? The answer is surprising. **Each day we consume about the same number of pounds of oxygen as we consume of food.** Were we to live in an oxygen-free environment, we would have to gather about as many pounds of oxygen each day as we do of food. Let's check this by calculation.

We need only be concerned with orders of magnitude—rounded numbers. (In estimates of this kind, illusions of accuracy arise when unwarranted significant figures are carried along.)

1) **A moderately active person consumes** about 3,000 kcal of energy per day. These calories might derive from an average daily food consumption of, say (1), 70 g **protein** (4.1 kcal/g), 70 g **fat** (9.3 kcal/g), and 500 g **carbohydrate** (4.1 kcal/g). Thus we consume some 640 g = 0.64 kg = **1.4 lb of food (dry weight) per day**.

2) A moderately active person might consume, on the average, 350 ml of O_2/min. This translates into 350 ml O_2/min × 60 min/h × 24 h/day = 500,000 ml O_2/day = 500 liters of O_2/day. To convert liters to grams we recall that, at normal temperature and pressure, one gram molecular weight of an ideal gas occupies 22.4 liters. Thus 500 liters of oxygen gas contain 500/22.4 = 22 mol of oxygen. Each mole of oxygen has a mass of 32 g (O_2: 2 × atomic weight = 2 × 16 = 32). It follows that **the moderately active person consumes** some 22 mol O_2 × 32 g O_2/mol = 700 g O_2 = 0.7 kg O_2 = **1.5 lb oxygen per day**.

3) **Conclusion: about 1.4 lb of food combines with about 1.5 lb of oxygen to provide the daily energy we need.**

This example portrays the power of number. Lord Kelvin once said, "You do not know until you measure." This might be restated, "You do not know until you have a number." Clinical medicine is obsessed with tests (numerical values for serum electrolytes, etc.). This is because what is a matter of life and death is not, for example, whether there is calcium in the blood, but how much calcium there is. When quantity is not taken into account, misconceptions easily develop about phenomena we think we understand. Calculation greatly enhances intuition.

Yet quantity is not everything. The systems theorist J. W. Forrester (lecture, Massachusetts Institute of Technology, 1969) notes that contemporary managers pay insufficient attention to the qualitative aspects of management; they attach too high a value to numerical data, to the detriment of their firms. Wisdom is the capacity to simultaneously entertain and reconcile extreme opposites (quality vs. quantity)—and everything that lies in between.

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