Back to the Future with SI Units

Among the many paradoxes which the United States exhibits is the fact that as a young republic it led the world in applying the decimal system to its currency, but two centuries later it is among the last countries of the world to apply the decimal system to other units of measurement. Although the US Congress enacted a Metric Conversion Act in 1975, we still measure length in feet and inches and weight in pounds and ounces. True, our speedometers now display kilometers in small numbers (that few notice), and media meteorologists pair Fahrenheit with Celsius (that most ignore); but these are small tokens of a change that is much larger and potentially far more drastic.

More progress has been made with measurements used in medicine. We no longer define low birthweight in pounds and ounces, and degrees Celsius appear on hospital charts. Nevertheless, many of the units still used in clinical chemistry rely on the weight of a substance (albeit expressed in gram) rather than the often more meaningful measure of chemical reaction equivalent expressed in moles.

In the last year or two, many American biomedical journals have decided to catch up with the rest of the world and require that a selected set of units belonging to the SI (System International), be used to report chemical and hematology values in submitted papers.[1-3] Basically, this means converting from mass to amount of substance (gram to

TABLE 1—SI Conversion Factors for Measurements Commonly Used in the American Journal of Public Health

Blood Chemistries	Present Symbol	Conversion Factor	SI Unit Symbol	Significant Digits	Suggested Minimum Increment
alpha-fetoprotein (S)	ng/mL	1.00	μg/L	XX	1 μg/L
alpha-fetoprotein (Amf)	mg/dL	10	mg/L	XX	1 mg/L
chloride (S)	mEq/L	1.00	mmol/L	XXX	1 mmol/L
cholesterol (P)	mg/dL	0.02586	mmol/L	X.XX	0.05 mmol/L
ethanol (P)	mg/dL	0.2171	mmol/L	XX	1 mmol/L
ferritin (S)	ng/mL	1.00	μg/L	XXO	10 μg/L
folate (S)	ng/mL	2.266	nmol/L	XX	2 nmol/L
glucagon (S)	pg/mL	1	ng/L	XXO	10 ng/L
glucose (P,S)	mg/dL	0.05551	mmol/L	XX.X	0.1 mmol/L
iron (S)	μg/L	0.1791	μmol/L	XX	1 μmol/L
lead (B,U)	mg/dL	48.26	μmol/L	X.XX	0.05 μmol/L
lipoproteins (P)*		(10)*	(g/L)*		
[LDL][HDL]	mg/dL	0.02586	mmol/L	X.XX	0.05 mmol/L
protoporphyrin (Erc)	μg/dL	0.0177	μmol/L	X.XX	0.02 μmol/L
sodium (S,U)	mEq/L	1.00	nmol/L	XXX	1 mmol/L
thiocyanate (P)	mg/dL	0.1722	mmol/L	X.XX	0.1 mmol/L
triglycerides (as triolein)	mg/dL	0.1129	mmol/L	X.XX	0.02 mmol/L
vitamin A (retinol)(P,S)	μg/dL	0.03491	μmol/L	X.XX	0.05 μmol/L
vitamin B_1 (thiamine hydrochloride (U)	μg/24 h	0.002965	μmol/d	X.XX	0.01 μmol/d
vitamin B_2 (S) (riboflavin)	μg/dL	26.57	nmol/L	XXX	5 nmol/L
vitamin B_6 (B) (pyridoxal)	ng/mL	5.982	nmol/L	XXX	5 nmol/L
vitamin B_{12} (P,S) (cyanocobalamin)	ng/dL	7.378	pmol/L	XXO	10 pmol/L
vitamin C(B,P,S) (ascorbate)	mg/dL	56.78	μmol/L	XO	10 μmol/L
vitamin D_3(P) (cholecalciferol)	μg/mL	2.599	nmol/L	XXX	5 nmol/L
vitamin E (P,S) (alpha-tocopherol)	mg/dL	23.22	μmol/L	XX	1 μmol/L
Hematology					
erythrocyte count (B)	10^6/mm^3	1	10^{12}/L	X.X	0.1 10^{12}/L
hematocrit	0/0	0.01	(1)	O.XX	0.01
hemoglobin (B) (mass concentration)	g/dL	10	g/L	XXX	1 g/L

Symbols

(1)	number one	Erc	Erythrocyte	n	nano (10^{-9})
Amf	amniotic fluid	g	gram	p	pico (10^{-12})
B	Blood	L	Liter	P	plasma
d	deci (10^{-1})	m	milli (10^{-3})	S	serum
		mol	mole	u	micro (10^{-6})

*Mole defined by Young[5] on the basis of cholesterol content. Lippert and Lehman[7] have suggested use of g/L rather than mole. This conversion factor appears in parentheses and is entirely acceptable.

moles) and using standard SI terminology for unit multiples and submultiples.

"SI" is the abbreviation for *le Système International d'Unités*, the result of over a century of international cooperation to develop a universally acceptable system of units of measurement for length, weight, time, chemical reactivity, temperature, electric current, and luminosity. All measures are derived from the base units used to measure these seven properties.

As Dr. van Assendelft points out in the informative Commentary which follows this editorial,[4] the shift from gram to mole and use of a standard multiple were recommended by the international chemistry community as the standards for expressing clinical laboratory results in medicine. The SI system itself would allow laboratories to express their results either in gram or moles, and either in liter or one of its sub-multiples. The chemistry community felt, with good reason, that a single standard was indicated.

Scientific journals are the watchdogs and style setters of science. In the United States their enforcement of a standard way of expressing clinical laboratory results is an important step to bring us in line with much of the rest of the world, to ease international comparisons and, in many cases, to lead to a better understanding of the relative amounts of body chemistry constituents and their interrelationships.

Clinical hematology and chemistry values are less often used in the *American Journal of Public Health* than in medical journals. Nevertheless, it has seemed appropriate to the Editorial Board for the Journal to require that we implement the recommendations of the chemistry community. I have reviewed the past two years of the Journal. I found one or two papers that were already using the mole as a base unit, but most papers relied on the gram. In the table which accompanies this editorial, the components I found in the Journal are listed together with the present units of mass used to measure them, the factor that converts the present units to the SI units recommended by the clinical pathologists, the accepted symbol for the SI unit, the recommended number of significant digits and suggested minimum increments. The list is far from comprehensive. Fuller descriptive information about SI units[4] and greatly expanded conversion tables for clinical laboratories will be found elsewhere.[5–7] Certain other measures commonly used in the Journal have been exempted from the shift to SI Units, at least for the time being. These are: rems and rads, calories and mm of mercury for blood pressure readings. Moreover, in the case of toxic chemicals and environmental pollutants not included in the clinical chemistry conversion tables,[5–7] we do not intend to insist on conversion to mole. As Dr. van Assendelft points out,[4] full implementation of SI in the medical community still awaits consensus.

We intend to begin requiring the use of the SI units recommended for use in medicine in 1988. For some period of time we will publish both conventional unit values and the selected SI unit values together. In time, we trust all readers will be as familiar with these SI unit values as they now are with the gram of birthweight.

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