

## THE MEASURE of all things

In the fifth century BC, the Greek philosopher Protagoras declared, "Man is the measure of all things", and for the next two millennia he was. But in the late twentieth century, it is the atom not the human which is becoming the standard against which all things are measured and compared. The passing of this baton heralds yet another phase in modern science's long history of displacing humanity from the centre of the cosmic scheme.

Through the ages, Protagoras's words have been taken literally, as well as metaphorically. For instance, in sixteenth century Germany, the "rood" was defined as the length obtained when sixteen men stood in a line and "put their feet together, one behind the other". The "foot" was defined as one-sixteenth of the rood, in essence the average length of sixteen men's feet. These were the formal standards by which land was to be measured and surveyed. Needless to say, in the age of science, a little more precision was called for and so, in 1875, a consortium of seventeen nations signed the Treaty of the Metre, which for the first time defined a precise international standard for weights and measures.

In place of sixteen men's feet, the new standard for length became the International Metre, a bar of platinum and iridium alloy which resides in a sealed case in a sealed vault beneath the headquarters of the International Bureau of Weights and Measures in Sèvres, France. Beside the International Metre is its equally auspicious cousin, the International Kilogram, a fist-sized cylinder of the same alloy which sits on a bed of quartz and is protected by three bell jars. For more than a century, this exotic duo have been the standards against which all length and weight have been calibrated. It has been their vital function to ensure that a kilogram of sugar in Sydney is equal to a kilogram of sugar in Tokyo, and that a metre of silk at Harrods is equal to a metre of silk at David Jones. According to physicist Hans Christian von Baeyer, this bar and this rod are "the sceptre and orb of the great empire of international industry and commerce".

**The standards by which we define the world are about to be turned upside down. In the twenty-first century, the atom will become our new yardstick.**

**Margaret Wertheim tries to gauge the implications**



The other great foundation stone of modern measurement is the second, a unit of time which has long been defined as one-sixtieth of one-sixtieth of one-twenty-fourth of the length of the day when the sun reaches its highest point in the sky. Until recently, these three things formed the backdrop against which the modern world was measured, but as science marches on it has demanded even more accuracy and so, like the feet of German men, they are all being replaced by far more precise standards, which can only be provided by the atomic realm.

The first to go was the second which, since 1967, has been defined in terms of the radiation emitted by atoms of cesium. So, instead of referring time to the daily rotation of our earth as people have done for aeons, it is now referred to something you must have completed a physics course to comprehend. And the new definition of the metre is the distance that light travels in  $1/299,792,458$  of a second. Thus, since the metre is now defined in terms of the second, ultimately it, too, is referred to the cesium atom. Similarly, other basic measures, such as the electrical volt, have also been redefined in terms of atoms.

The one remaining bulwark is the International Kilogram which, for the moment, is still the standard for weight, although not for much longer. In his recent book, *Taming the Atom*, von Baeyer says that the kilogram, too, will soon be defined in atomic terms. Then, like its cousin, the platinum and iridium cylinder in Sèvres, it will be nothing more than "a quaint museum piece". "The loss of this faithful assistant who has served without fail for more than a century is sad," says von Baeyer. This is not sentimental silliness, for when the International Kilogram is put out to pasture, "science will be taking another step towards inscrutability". Instead of relating to tangible commonsense standards, which ordinary men and women intuitively comprehend, all our weights and measures will be tied to things that even most physicists would be hard pressed to explain. As the atom replaces man as the measure of all things, it is the "loss of contact with common sense" for which von Baeyer mourns.