Subject: Scholes Cabin 5 (P): Orders of magnitude

17 January 2010 0537 UTM 69.3380 S 1.8636 W

Dear Stirling

As you can see, we are making good progress. We had to sail a bit east to clear the worst pack-ice, but now we are heading northeast fairly steadily. There is still a lot of mushy ice around, but mostly it does not stop us.

I need you to learn about orders of magnitude to get ready for an email I will send you later. I don't think you have done them at school yet (be patient with me if you have), but it is a really useful concept. Simple really - for numbers bigger than one you just have to count how many digits there are between the beginning of the number and the decimal point, then subtract one. That is the 'order of magnitude'. So all numbers between 10 and 99 have an order of magnitude of 1, numbers from 100 to 999 have an order of magnitude 2, and so on. For numbers smaller than one, count how many digits between the decimal point and the first non-zero digit and add one.

So the fraction 0.03 has an order of magnitude of -2, and 0.00726 has order of magnitude -3.

So why is that useful? Because it allows us to work easily with very big numbers and very small numbers, even in the same equation. Firstly, it gives us a shorthand for writing them down, called 'scientific notation'. For example, the number 4223692 is approximately 4.2E6 while 0.0000021 is 2.1E-6. The E stands for 'exponent', which means the order of magnitude, since we are working in the decimal system. (You could also write it as 4.2 x 10 raised to the little 6, but I don't have superscripts in this email, so I won't!). Secondly it allows you to do quick approximate sums, because when you multiply two numbers in scientific notation, you just add the exponents; and when you divide one number by another, you subtract the exponents. So the product of the two numbers above is about 8.8E0 (in other words, 8.8), while the first divided by the second is 2.0E12. There are some other little tricks, but that is enough for now.

It gets a bit awkward always saying 'ten to the power fifteen' or whatever, so there are special adjectives - a sort of mathematics language. We are lazy and only learn the words (and their abbreviations) for every third order of magnitude: k for kilo (E3), M for mega (E6), G for giga (E9) ...one I use quite a lot is P for peta (E15), because that is how many grams of carbon people cause to be put into the atmosphere every year - a big number. There are words for the small orders too: m for milli (E-3, notice that we write small m, so we don't get confused with Mega); mu - that is a Greek letter like a backwards u - for micro (E-6) and n for nano (E-9). Single molecules are a bit smaller than a nanometre (in other words, a billionth of a metre), which is why they call

inventions that use the special properties of tiny particles 'nanotechnology'. Single viruses are about a nanometre across, and the whole world ecosystem is about 1.3E7 metres, so that sort of brackets the size range of biology: sixteen orders of magnitude! What is the biggest thing in the universe? And the littlest (known) thing? How many orders of magnitude is that?

Enough sums! I had a quiet night because we can't use the UCTD until we get clear of the pack-ice, and my instruments are behaving themselves for once.

Love,

Dad