(3) Estimate the length of the longest free path experienced by a nitrogen molecule in the lowest kilometer of the Earth's atmosphere during the last billion years.

The lowest kilometer of the atmosphere contains $10^{43}$ nitrogen molecules with mean free path $\bar{l}$ of $10^{-5}$ cm and speed $5 \times 10^4$ cm/s. The number of free paths in $10^9$ years, call it $N$, is $1.5 \times 10^{69}$. If $\bar{l}$ had been always and everywhere the same, the distributions of path lengths would have been exponential, and the probability would be 0.5 that the longest of the $N$ paths exceeded $\bar{l} \ln(2N) = 160l = 0.0016$ cm. But what about rare occurrences of abnormally low pressure, for instance, tornadoes? At half the pressure $\bar{l}$ would be doubled, and a path as long as 0.002 cm would be found among a sample of only $10^{44}$ paths. That many occur in one hour in $10^5$ m$^3$. Perhaps the only safe statement we can make is something like this: the longest free path probably occurred during some rare event in which the local pressure dropped to a fraction $f$ of 1 atm. It was longer than 0.002 cm, but not longer than $100 \times (10^{-5}/f)$ or $10^{-3}/f$ cm. (How the word *local* is to be understood in this context is an intriguing question.)