Phosphorus from supernovae: a path to life on Earth?

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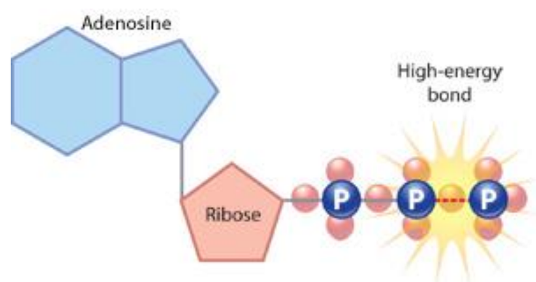
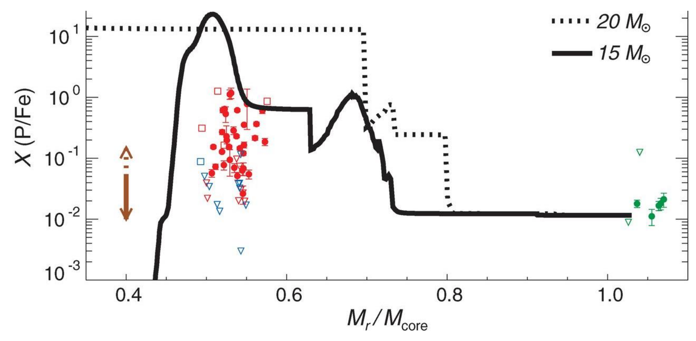
Phosphorus (P) is critical to life: e.g. cells use adenosine triphosphate (ATP) to regulate and transfer energy.

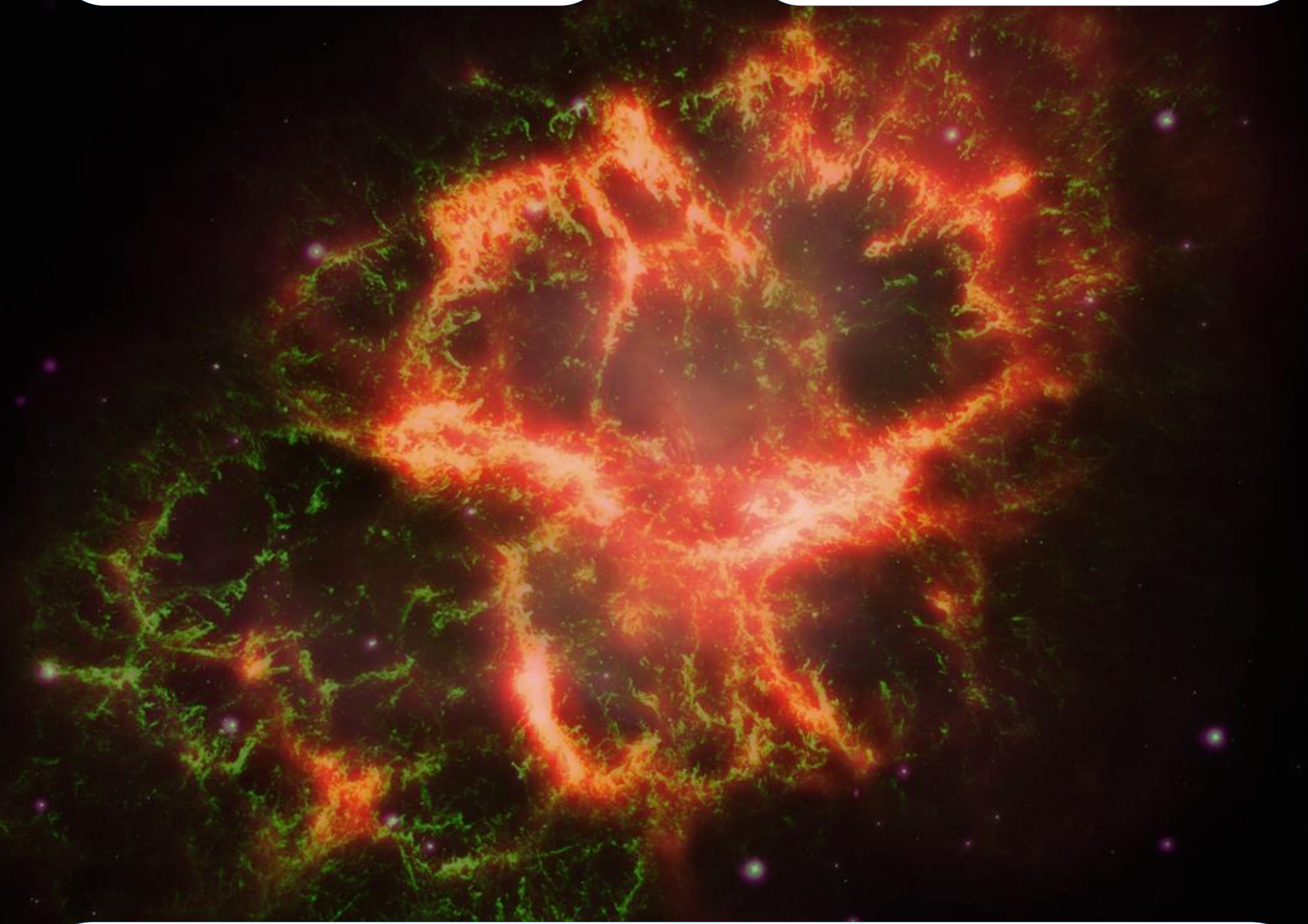


P tends to be unreactive. Pasek et al. (2008, 2013) propose that meteorites delivered reactive P-bearing minerals such as schreibersite to the young Earth, which when dissolved in water, helped to produce proto-biomolecules.

P originates mainly in supernovae. Two problems:

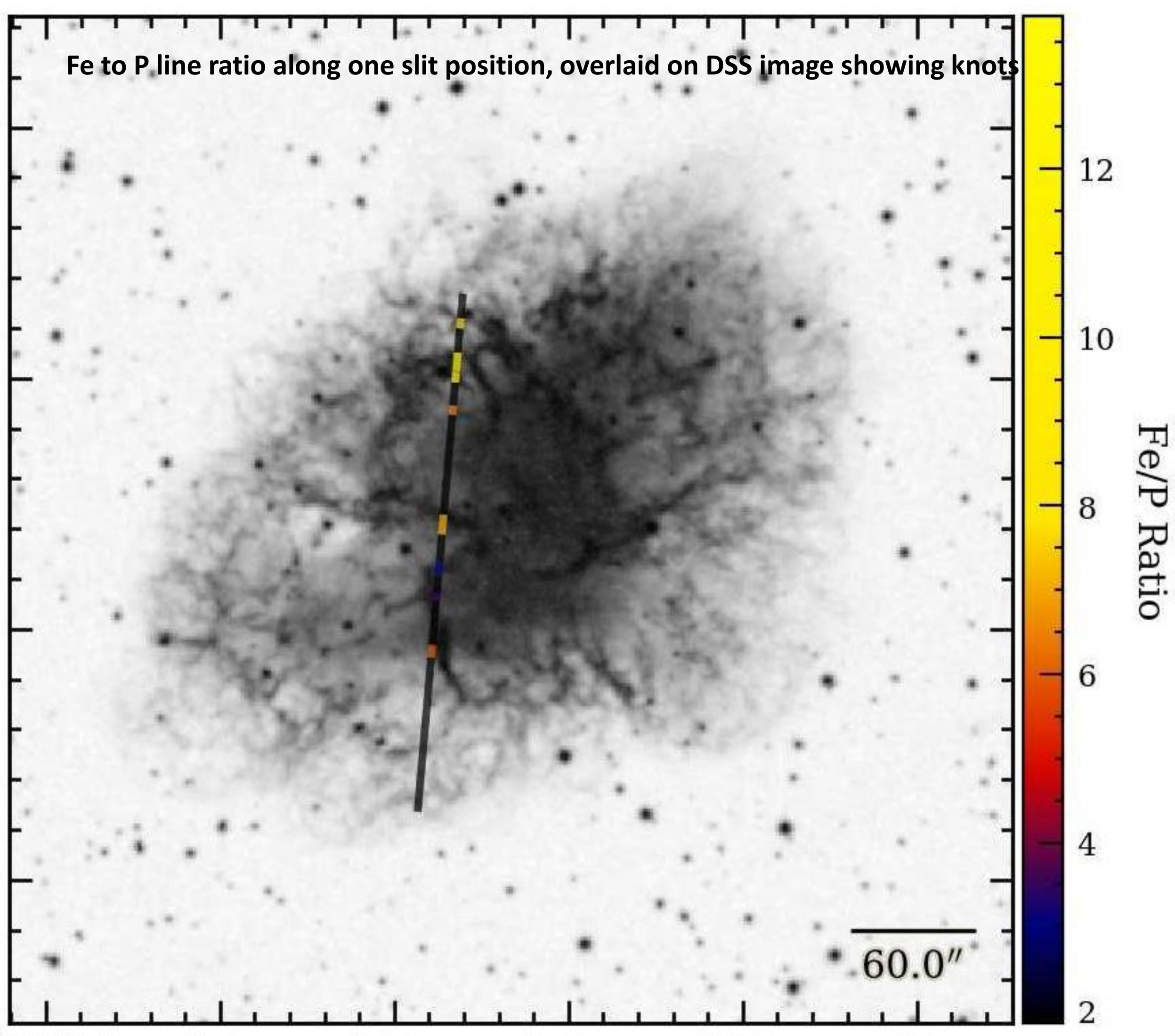
- SN models under-predict P by factors ~3 compared to P inherited later by e.g. the Sun (Cescutti et al. 2012)
- the only supernova remnant observed in P shows ejected knots with wide-ranging (P:Fe) (Koo et al., 2013: Cas A)

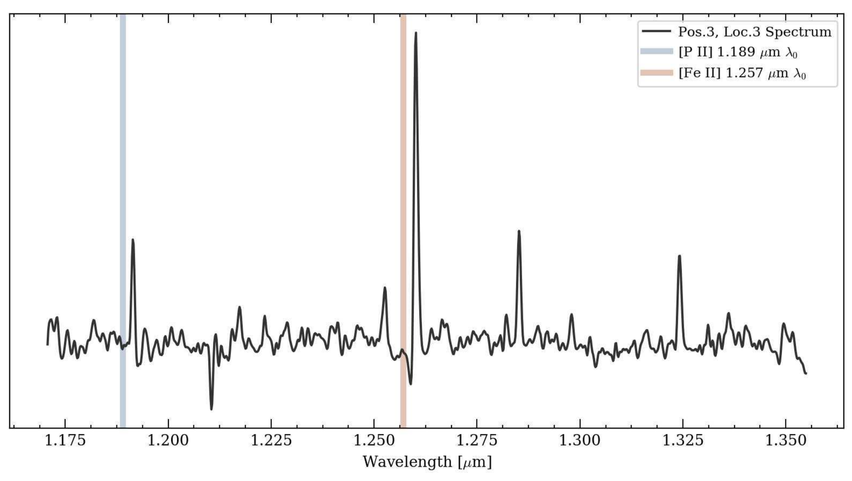




background image: composite of IR (red), visible (green) and UV (violet) images of the Crab Nebula, via public.nrao.edu/color/ with IR enhanced and visible/UV balanced to yield neutral star colours

HYPOTHESIS: P spat out by a random SN event could end up in a nearby young terrestrial planet in highly unpredictable abundance. **This might stimulate or hinder life originating.** The solar system may be 'lucky', having been enriched in massive-star products (such as radio-isotopes, e.g. Fujimoto et al. 2018). To **TEST** this we obtained P, Fe spectra for the Crab Nebula using the WHT, and compared them to Cas A. **RESULTS**: we saw **no** knots in the Crab where PII/1.189μm is brighter than FeII/1.257μm, although these are common in Cas A. The difference may be due to progenitor mass (Cas A: ~15-25 M_{Sun}, Crab: ~8-10 M_{Sun}). **CONCLUSION**: When Crab ejecta are blended with unenriched interstellar gas, this material could be phosphorus-poor. If massive progenitors like that of Cas A are rarer, the Crab may represent a more typical injection of phosphorus in regions where next-generation stars are forming.





example WHT spectrum; knots speeds are up to ~1000 km/s

number of knots with estimated X(P/Fe)
(solar = 1 on x-axis)