# A Hitchhikers Guide to the Black Arts
## (of Earth system modelling)

**XX**: Preformed nutrient tracers of ocean biogeochemical cycling

# 20. Preformed tracers of ocean biogeochemical cycling

20.0 You will be using a 'modern' configuration of *c*GENIE, but … it is rather more idealized than you have seen for the modern Earth in previous Labs (although not quite as idealized as for the snowball Earth experiments). It also differs from many of the previous experiments in that is not only has an ocean carbon cycle but also co-limitation by iron.

Note that as you will be using a new *c*GENIE configuration, so before you forget ... you need to run a `make cleanall`.

Also: you will need to download (to `cgenie_output`) and uncompress a new restart:

$ `wget http://www.seao2.info/cgenie/labs/Caltech.2013/EXAMPLE.p0000e.PO4Fe.PREFORMED.tar.gz`

$ `tar xfzv EXAMPLE.p0000e.PO4Fe.PREFORMED.tar.gz`

(and return to `genie-main`)

20.1 A template experiment is provided: `exp20_modernlores_CONTROL`. This can be run in conjunction with a new *base-config* (`cgenie.eb_go_gs_ac_bg.p0000e.BASESFerb`) and the restart (`EXAMPLE.p0000e.PO4Fe.PREFORMED`) by:

$ `./runmuffin.sh cgenie.eb_go_gs_ac_bg.p0000e.BASESFerb`
` LABS exp20_modernlores_CONTROL 1000 EXAMPLE.p0000e.PO4Fe.PREFORMED`

The *base-config* (`cgenie.eb_go_gs_ac_bg.p0000e.BASESFerb`) is different from before and includes an iron cycle alongside phosphate as a limiting nutrient (the 'Fe' bit). The resolution is also notably degraded resolution (and fewer time-steps per year) and is specified here simply to allow new steady states of ocean carbon cycling to be achieved within a reasonably short amount of (real) time. Unfortunately, that the resolution is rather more degraded than previously means that you will need to be aware of additional limitations and caveats associated with this configuration (these limitations and caveats are left for <u>you</u> to identify and take on board).

The restoring of atmospheric $p$CO$_2$ and $\delta^{13}$C has been removed in `exp20_modernlores_CONTROL` compared to the *spin-up* (`EXAMPLE.p0000e.PO4Fe.PREFORMED`) and as configured, will act as a control – assessing whether the *spin-up* really was genuinely spun-up.

The important feature of the *user-config* and *base-config* pair is the introduction of color tracers and specification that the 'red' one acts as a tracer for preformed PO$_4$. (In a configuration including nitrate (not this particular one), the blue tracer would track preformed nitrate.)

20.2 What to 'do'? Play with the biological pump strength – read through the list of *user-config* parameters – parameters that affect export include:
`biological uptake time-scale – bg_par_bio_tau`
`aeolian Fe solubility -- bg_par_det_Fe_sol`
Also, parameter that affect how 'efficient' the biological pump is, e.g.
`depth of remineralization or particulate organic matter -- bg_par_bio_remin_POC_eL1`
etc.
Adjust the values, re-run (maybe for 1000 years, maybe longer is needed – you could/should find out) and re-assess the preformed distribution (netCDF) and also inventory compared to PO$_4$ (e.g. time-series ASCII file output).

Changes in ocean circulation could potentially also be induced. The parameters ('hidden' in the *base-config* file):
`diffusivity scaling factor -- ea_diffa_scl=0.2`
`grid point distance over which scalar is applied (j direction) – ea_diffa_len=3`
control how heat diffuses to far southern latitudes and hence how cold the Southern Ocean is (and sea-ice extent). For instance, setting: `ea_diffa_scl=1.0` in removing any suppression of diffusion might (or might not) create an interesting perturbation of ocean circulation. (An Atlantic hosing forcing could also be added.)

Additional questions would include how atmospheric $p$CO$_2$ and $d^{13}$C relate to diagnosed changes in preformed PO$_4$.

20.3  It is also possible to have preformed tracers and red/blue numerical color tracers. An alternative *base-config* has been provided that configures this:

`cgenie.eb_go_gs_ac_bg.p0000e.BASESFerbcolx`

(Remember to `make cleanall` as the number of selected tracers in the ocean has now increased.)

The preformed tracers in both time-series and time-slice format are grouped under '`misc`' and labeled with the dissolved tracer they represent. (They also additionally appear under the ocean tracer list.)