Magnetic anisotropy is a fundamental property of magnetic materials that governs the stability and directionality of their magnetization. The ability to control the magnetic anisotropy of nanoscale systems will open novel avenues for spintronics, magnetic memory devices, and quantum computation. At the atomic level, magnetic anisotropy originates from the spin-orbit coupling that connects the spin moment of a magnetic atom to the spatial symmetry of its ligand or crystal field environment. In the case of 3d transition metal atoms, the same crystal field that is necessary for the anisotropy usually quenches the orbital moment and reduces the total magnetic moment of the atom to its spin component. As a result, single molecule magnets and magnetic tunnel junctions show an anisotropy energy per atom that is typically one to two orders of magnitude smaller than the maximal value allowed by the spin-orbit coupling. We have overcome this limitation by carefully designing the coordination geometry of magnetic atoms on a surface to preserve the orbital moment while inducing uniaxial anisotropy. I will present scanning tunneling spectroscopy and x-ray absorption spectroscopy measurements that show that single Cobalt atoms deposited on a thin MgO layer retain most of their free-atom orbital moment $L=3$. Because Cobalt adsorbs on top of the Oxygen atom, the resulting crystal field is effectively cylindrical and leads to a strikingly large magnetic anisotropy energy, at the theoretical limit. Spin-polarized tunneling measurements reveal a stable magnetic groundstate with a large total moment of $\sim 5.5 \mu_B$ and a long-lived excited state of opposite magnetic moment with a relaxation time of 0.2 ms. These results offer a strategy, based on symmetry arguments and careful tailoring of the interaction with the environment for the rational design of nanoscopic permanent magnets and single atom magnets.