The physics case for a polarized $e-p$ collider has been studied rather extensively at a number of recent workshops Several proposals exist, e.g. for HERA, eRHIC/EPIC and THERA. Onoe of the main aims will be to measure the polarised structure of matter. For the proton there are two spin independent structure functions $F_1(x,Q^2)$ and $F_2(x,Q^2)$ which are determined by electromagnetic unpolarized $e-p$ scattering. One of the principal interests and accomplishments of HERA research has been the accurate measurement of F_2 for very small x and high Q^2 and the observation of the rapid rise of F_2 at small x. This has provided a critical test of perturbative quantum chromodynamics (pQCD) in the region where the gluon density is high and it is of major theoretical interest. The spin dependent structure function $g_1(x,Q^2)$ provides information on the spin structure of the proton and is of comparable importance to F_2. It will be most valuable to extend greatly with a polarised ep collider the kinematic range of information on g_1. With present fixed target data on $g_1(x,Q^2)$ the range is $0.003 < x < 0.7$ with $1 < Q^2 < 60$ GeV^2. A polarized collider would extend the region to lower x by a factor of 10 to 1000 and to higher Q^2 also by a factor of 10 to 1000.

pQCD predicts that $g_1(x,Q^2)$ will decrease dramatically at low x where the gluon density is high, in contrast to the observed rapid rise in F_2 at low x. Such behaviour would provide an important test of pQCD. In particular, g_1 is sensitive to large logarithms of $1/x$, having a $(\ln 1/x)^2$ dependence, and thus putative low–x effects are much more strongly enhanced than for non–polarized structure function measurements.

With a polarised collider data on $g_1(x,Q^2)$ the polarized gluon distribution function $\Delta G(x,Q^2)$ and its first moment $\int_0^1 \Delta G(x,Q^2)dx$ could be determined through the equations for pQCD. The quantities $\Delta G(x,Q^2)$ and $\int_0^1 \Delta G(x,Q^2)dx$ which are of central importance for the proton spin structure, are largely unknown at present and are needed to solve the nucleon spin puzzle. This is the main focus of the COMPASS experiment at CERN and the experiments at RHIC which will collect polarized $p-p$ data. The big trump card of $e-p$ collisions at high energy at eRHIC, HERA or TESLA is the additional sensitivity to the polarized gluon density via photon gluon fusion (PGF) processes through direct observation of, for example, dijets. Realistic studies of the data obtainable on $g_1(x,Q^2)$ and on ΔG from dijets, which include NLO treatment, detector characteristics and radiative corrections indicate that the data will be accurate and useful. Apart from using dijets, the polarized gluon distribution can be accessed by analyzing events with high p_T tracks, via forward–backward particle asymmetries, and in jet and particle production in photoproduction events. In all, a polarised collider can access the polarized gluon distribution in a variety of different ways, allowing the gluon density to be pinned down.

Most of the topics studied now at HERA with unpolarized protons have their counterpart in polarized $e-p$ scattering. A few examples are the polarized structure function g_5, which allows to access the polarized parton distributions of different quark flavours separately; photoproduction which gives a unique opportunity to measure and study the polarized parton distribution in the photon, an entirely unexplored area as far as existing data is concerned; the disentangling of a chiral structure of any observed anomaly, and extending search limits for new phenomena at large Q^2; the study of polarization effects in diffraction in deep inelastic scattering which were found to be a potential referee on the perturbative or non–perturbative nature of this phenomenon; study of polarization effects in the proton target region to further understand target universality; measuring the transition from zero Q^2 to a few GeV^2 etc.