24.1.1. ***Leptoproduction cross sections***:

$$\frac{d^2\sigma}{dx\,dy} = \nu\,(s - M^2)\,\frac{d^2\sigma}{d\nu\,dQ^2} = \frac{2\pi\,M\nu}{E'}\frac{d^2\sigma}{d\Omega_{\text{lab}}\,dE'}$$

$$= x(s - M^2)\,\frac{d^2\sigma}{dx\,dQ^2}\ . \tag{24.1}$$

24.1.2. ***Electroproduction structure functions***: The neutral-current process, $eN \to eX$, is parity conserving at low Q^2 and can be written in terms of two structure functions $F_1^{\text{NC}}(x, Q^2)$ and $F_2^{\text{NC}}(x, Q^2)$:

$$\frac{d^2\sigma}{dx\,dy} = \frac{4\pi\,\alpha^2(s - M^2)}{Q^4}$$

$$\times\left[(1-y)\,F_2^{\text{NC}} + y^2\,xF_1^{\text{NC}} - \frac{M^2}{(s-M^2)}\,xy\,F_2^{\text{NC}}\right]\ . \tag{24.2}$$

The charged-current processes, $e^-N \to \nu X$, $\nu N \to e^- X$, and $\overline{\nu}N \to e^+X$, are parity violating and can be written in terms of three structure functions $F_1^{\text{CC}}(x, Q^2)$, $F_2^{\text{CC}}(x, Q^2)$, and $F_3^{\text{CC}}(x, Q^2)$:

$$\frac{d^2\sigma}{dx\,dy} = \frac{G_F^2\,(s - M^2)}{2\pi}\frac{M_W^4}{(Q^2 + M_W^2)^2} \tag{24.3}$$

$$\times\ \left\{\left[1 - y - \frac{M^2xy}{(s-M^2)}\right]F_2^{\text{CC}} + \frac{y^2}{2}\,2x\,F_1^{\text{CC}} \pm (y - \frac{y^2}{2})\,x\,F_3^{\text{CC}}\right\}\ ,$$

where the last term is positive for the e^- and ν reactions and negative for $\overline{\nu}N \to e^+X$.

24.1.3. ***The QCD parton model***: In the QCD parton model, the structure functions defined above can be expressed in terms of parton distribution functions. The quantity $f_i(x, Q^2)dx$ is the probability that a parton of type i (quark, antiquark, or gluon), carries a momentum fraction between x and $x + dx$ of the nucleon's momentum in a frame where the nucleon's momentum is large. For the cross section corresponding to the *neutral-current process* $ep \to eX$, we have for $s \gg M^2$ (in the case where the incoming electron is either left- (L) or right- (R) handed):

$$\frac{d^2\sigma}{dx\,dy} = \frac{\pi\alpha^2}{sx^2\,y^2}\left[\sum_q(x\,f_q\,(x,\,Q^2) + x\,f_{\overline{q}}\,(x,\,Q^2)\right]$$

$$\times\left[A_q + (1-y)^2\,B_q\right]\ . \tag{24.4}$$