Appendix C
Summary of primary results

The important definitions and results are, quite naturally, spread throughout the book. However, it is frequently convenient for reference purposes to have all these equations collected together. This will be the purpose of this appendix.

Lagrangian and Feynman rules of QCD

Without regard to renormalization see (2.1) for the gauge-invariant Lagrangian, and see Sec. 3.1.2 and Fig. 3.1 for the gauge-fixed Lagrangian and the Feynman rules. See (3.6) for the BRST transformations.

With counterterms, etc., see (3.13), (3.14), and (3.15) for the Lagrangian, and Fig. 3.2 for the counterterm vertices.

The full Standard Model Lagrangian is given in (2.30).

Definition of $\overline{\text{MS}}$

See Sec. 3.2.6 for the definition of the $\overline{\text{MS}}$ renormalization scheme.

Renormalization counterterms, RG coefficients

The results for one-loop renormalization counterterms in Z_2, m_0, Z_3, $\tilde{Z}$, and g_0 are in (3.23), (3.24), (3.25), (3.26), and (3.31). The higher orders are left as an exercise to be derived from the RG coefficients (problem 3.2).

The renormalization group coefficients (β, etc.) are given in Sec. 3.7.

Information on relating schemes with different numbers of active quark flavors is given in Sec. 3.10.

Light-front perturbation theory, etc.

The rules for light-front perturbation theory are given in Sec. 7.2.3.

Light-front wave functions are defined in Sec. 7.3.

Parton densities

The operator definition of an unintegrated quark density in the parton-model framework is given in (6.31), while the antiquark density is given in (6.33). The corresponding polarized densities are given in (6.35) and (6.36). The unintegrated (TMD) quark density is defined in (6.79). Isospin and charge-conjugation relations are listed in Sec. 6.9.7.

Feynman rules for the above densities, still in a pre-QCD framework, are given in (6.110) and in Fig. 6.7. For an unintegrated (TMD) density, see Fig. 6.8.

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Gauge-invariant unrenormalized integrated parton densities are defined in (7.40) (quark), (7.43) (unpolarized gluon), (7.44) (polarized gluon). Feynman rules for these are given in Figs. 7.9, 7.10, 7.11, and 7.12.

Our convention for the renormalization factors for parton densities is given in (8.11). Our convention for the DGLAP kernel is in (8.30).

One-loop results for the DGLAP kernels are given in (9.6) (quark in gluon), (9.23) (quark in quark), (9.24) (gluon in gluon), and (9.25) (gluon in quark).

For TMD parton densities in QCD there are a number of extra polarization-dependent functions which are defined in Sec. 13.16. These include the Boer-Mulders function, the Sivers function, and the pretzelosity distribution.

Fragmentation functions

The basic non-QCD definitions of fragmentation functions are given in Sec. 12.4.

In QCD, unrenormalized fragmentation functions are defined in (12.71) (quark) and (12.72) (gluon). The situation on the DGLAP kernels for the renormalized QCD fragmentation functions is summarized in Sec. 12.10.4.

Flavor relations are given in (12.43).

Definitions and results for deeply inelastic lepton scattering

The kinematics of DIS are defined in Sec. 2.3.2, and the structure functions in the electromagnetic case are defined in (2.20) and (2.21). Structure functions are related to the DIS cross section in (2.22).

The parton-model result for DIS is given in (2.28) and (2.29) for the unpolarized case, and in (6.25) when target polarization is included.

In the case of charged-current neutrino and antineutrino scattering on an unpolarized target, the structure functions are defined in (7.3) and the parton-model formula is given in (7.5) and (7.6).

e^+e^- annihilation total cross section

The results of perturbative calculations of the ratio R for the total cross section for $e^+e^- \to$ hadrons are given in (4.34).

Power-counting and region analysis

The power that corresponds to a general region for a hard process is given in (5.75), (5.76), (5.77), (5.78).

Factorization formulae for DIS

Factorization for DIS structure functions is stated in (8.83).

The one-loop coefficient function is in (9.43) (gluon) and (9.54) (quark). With a quark mass, the gluonic coefficients are given in (9.55) and (9.58). References to the currently known higher-order terms are given in Sec. 9.12.

Factorization for Sudakov form factor

The final form of the collinear factors for the Sudakov form factor is defined in (10.119), with the evolution kernel defined in (10.122). Factorization and evolution formulae are given in Sec. 10.11.4, with a solution in (10.131) for the factorized form factor.

The two-loop result for γ_K is given in (10.135). The one-loop hard factor is given in (10.146).

One-particle-inclusive e^+e^- annihilation

For the one-particle-inclusive e^+e^- annihilation process, the hadronic tensor and structure functions are defined in Sec. 12.1, and formulae for the cross section are given.

The factorization formula for the cross section is given in (12.13). Factorization formulae for the hadronic tensor and for the structure functions are given in Secs. 12.2.3 and 12.2.4.

The LO coefficient functions are in Sec. 12.3.

The NLO coefficient functions are discussed in Sec. 12.11, with references to the results.

Semi-inclusive DIS (SIDIS)

Factorization for the SIDIS cross section is stated in the form with integrated parton densities and fragmentation functions in (12.95).

Two-particle annihilation in e^+e^- annihilation

The kinematics, the hadronic tensor, and cross section formulae for two-particle annihilation in e^+e^- annihilation are given in Sec. 13.2.

TMD factorization for two-particle annihilation in e^+e^- annihilation

For TMD factorization, the bare soft factor is defined in (13.39). The unpolarized TMD fragmentation function is defined in (13.42), with the unsubtracted fragmentation function defined in (13.41) as an operator matrix element.

TMD factorization for two-particle annihilation in e^+e^- annihilation is stated in (13.46). The CSS and RG evolution equations are given in Sec. 13.8.

The one-loop results for the CSS evolution kernel K and its anomalous dimension γ_K are given in (13.55) and (13.56). The separation of the non-perturbative part of K is performed in Sec. 13.10.4, especially at (13.60).

The result of solving all the evolution equations is presented in three forms in Sec. 13.13.

The results of calculations of the NLO term for the small-b_T behavior of TMD fragmentation functions are given in (13.92) (gluon from quark) and (13.100) (quark from quark).

The corresponding results for large k_T are in (13.93) (gluon from quark) and (13.101) (quark from quark).

TMD factorization for SIDIS

The TMD quark densities are defined in (13.106), the unsubtracted density being defined in (13.108) as an operator matrix element. These definitions are the ones with future-pointing Wilson lines to be used for SIDIS.

TMD factorization for SIDIS is stated in (13.116).

TMD factorization for Drell-Yan

TMD factorization for Drell-Yan is stated in (14.31). The results of fits to the TMD non-perturbative functions are reviewed in Sec. 14.5.3.