point functions. Therefore correlation functions are of paramount importance in quantum field theory. As an example, consider the four-point function

$$\langle 0| T\left[Q\left(x_1\right)\bar{Q}\left(x_2\right)Q\left(x_3\right)\bar{Q}\left(x_4\right)\right]|0\rangle\,. \tag{1.15}$$

Correlation functions of this form can be evaluated using Wick's theorem, which can be used to express any time ordered product in terms of Feynman propagators and normal ordered products. For the time ordered product in (1.15), Wick's theorem yields

$$\begin{aligned} T\left[Q\left(x_1\right)\bar{Q}\left(x_2\right)Q\left(x_3\right)\bar{Q}\left(x_4\right)\right] &= \,:Q\left(x_1\right)\bar{Q}\left(x_2\right)Q\left(x_3\right)\bar{Q}\left(x_4\right): \\ &+ \wick{\c1 Q\left(x_1\right)\c1 {\bar{Q}}\left(x_2\right)}:Q\left(x_3\right)\bar{Q}\left(x_4\right): \\ &+ :Q\left(x_1\right)\bar{Q}\left(x_2\right):\wick{\c1 Q\left(x_3\right)\c1 {\bar{Q}}\left(x_4\right)} \\ &+ \wick{\c1 Q\left(x_1\right)\c1 {\bar{Q}}\left(x_2\right)\c2 Q\left(x_3\right)\c2 {\bar{Q}}\left(x_4\right)} \\ &+ \wick{\c1 Q\left(x_1\right)\c2 {\bar{Q}}\left(x_2\right)\c2 Q\left(x_3\right)\c1 {\bar{Q}}\left(x_4\right)}\;. \end{aligned} \tag{1.16}$$

The contraction of the quark fields is defined as

$$\wick{\c1 Q\left(x\right)\c1 {\bar{Q}}\left(y\right)} = S\left(x-y\right)\;, \tag{1.17}$$

where $S\left(x-y\right)$ is the quark propagator (1.14). Note that in the last line of Eq. (1.16) there are contractions where the fields are not adjacent and are not in the same order as those in (1.17). The quark fields can be moved so that they are adjacent and in the proper order using the anticommutator algebra (1.8). Wick's theorem yields the following for the correlation function:

$$\begin{aligned} \langle 0| T\left[Q\left(x_1\right)\bar{Q}\left(x_2\right)Q\left(x_3\right)\bar{Q}\left(x_4\right)\right]|0\rangle &= S\left(x_1-x_2\right)S\left(x_3-x_4\right) \\ &- S\left(x_3-x_2\right)S\left(x_1-x_4\right)\;, \end{aligned} \tag{1.18}$$

where we have used the fact that vacuum expectation values of normal ordered products are identically zero. Wick's theorem is valid for all quantum fields, and can be generalized to time ordered products involving any number of fields.