A couple of notes for quarks[1][2]

- The light-quark states [made of u(up), d(down), and s(strange)] are much more difficult to deal with since they are intrinsically relativistic.
- Quantum Field Theory (QFT) is not well suited to bound-state problems. This is because a bound-state arises nonperturbative interactions.
- Although light-quark sectors are relativistic, the heavy quarks are not.

The operator

$$D_\mu \equiv \partial_\mu + igT^\alpha_{ij}A^a_{|mu}$$

where g is the gauge coupling constant, which can also be expressed as $\sqrt{4\pi\alpha}$. The constant α is based on system. $(T^\alpha)_{ij}$ is the generators of the Lie group which defines the gauge symmetry. For SU(3), there are 8 generators. The generator can also be expressed as $\frac{\lambda_{alpha}}{2}$ and λ_α is known as Gell-Mann matrices[3].

- A quark carries 3 color charges.
- An anti-quark carries 3 anti-color charges.
- Thus, gluon carries $3 \times 3 - 1 = 8$ charges. The term, -1 is the singlet state of white color to be removed.

References

[1] D. Griffths, *Introduction to Elementary Particles*. Wiley, 2008

[2] G. V. Efimov, *On bound states in quantum field theory* (1996)

[3] G. Dissertori, et. al. *Quantum Chromodynamics*.Oxford Univ. Press, 2009