Evidence supporting the idea of quarks as the hadronic constituents has been strengthening since they were first proposed by Gell-Mann and Zweig in the 1960's. In particular there are the successes of the SU(3) symmetry scheme. Hadrons of the same spin and parity form multiplets each of which corresponds to an irreducible representation of SU(3). Experimentally the multiplets are observed to be octets, decuplets, and singlets, whereas the fundamental representation of SU(3) is a triplet. Therefore the simplest picture of hadrons is to build them as bound states of triplet quarks from which they derive their individual quantum numbers of electric charge, strangeness, etc.

Moreover, beyond their simple and attractive role in the group theoretic structure of hadrons, the quarks, though still unobserved, have acquired strong support from phenomenological analyses of hadronic properties and interactions. Among these successes of the quark model we include:

1) Static properties such as mass spectra of hadrons and low lying resonances
2) Transition matrix elements
3) Quark recombination rules (viz. Zweig's rule) for dual models and graphs
4) The quark-parton description of deep inelastic electron and neutrino scattering
5) Quark line counting rules for scaling laws in large transverse momentum exchange processes and the constituent interchange model
6) Constancy of the hadron to muon production ratio in electron-positron annihilation, in between thresholds for the onset of "new physics."

Despite these impressive successes several issues must be resolved before a real understanding of hadron dynamics based on the quark idea is possible:

1) Why do we not see isolated quarks?
2) In the observed hadronic spectroscopy, why do the quarks appear to obey symmetric statistics in spite of their half-integer spin?

The second of these issues is resolved by adopting the "color hypothesis." A hidden SU(3) of color is introduced together with the assertion that the dynamics permits only color singlet states to be bound to form hadrons. In effect the anomalous quark

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Statistics are avoided by tripling the number of quarks (analogously to the introduction of electron spin doubling the number of electron states).

However the nonobservation of isolated quarks is a new one to particle physics.* Are they permanently confined, never to be observed as isolated particles? Or are they so heavy when they are isolated from the extremely strong forces binding them as effectively light constituents within hadrons to form color singlet—or zero triality—states that their production thresholds lie above presently observable energies ($M_{\text{quark}} > 10 \, \text{GeV}$)?

Theoretical efforts to understand quark confinement have developed along both lines—of permanent and of approximate quark confinement. I will be discussing in these lectures primarily an effort to understand approximate quark confinement that is based on the conservative approach of local canonical quantum field theory, with the quark fields included among the fundamental fields of the theory when it comes to writing interaction currents and forming asymptotic states. It is physically clear that weak coupling perturbative expansions are quite hopeless in such an approach. By no reasonable approximation can they span the gap between the starting point of a bare vacuum and a Fock space of free quark states created from this vacuum by interaction representation fields on one hand, and the observed hadronic spectrum of low lying quark bound states with a binding so strong that it essentially cancels their large bare masses.

An alternative class of models¹ that I will not discuss is that in which the fundamental fields do not create asymptotic states at all. In such "long range force models" one has contrasting behaviors at short distances and at long distances. At short distances the forces seem to weaken to the point that free field theory scaling laws are applicable and one speaks of asymptotic freedom at high energies. At large distances the opposite is assumed to occur: the forces grow so strong that the fundamental fields do not create asymptotic states. In particular the bonds between quarks cannot be broken and they are bound permanently to one another by flux lines due to their color charges or monopole moments. However, if a particle is in a color singlet state so that no flux lines are emerging from it it will not be bonded to an additional quark. This general idea was first explored by Schwinger¹ in two dimensional quantum electrodynamics. When summed to all orders in the coupling, the infrared singularities in Green's functions involving bare quark lines are so severe that they

*Although not a new one to the Bible, I thank V. F. Weisskopf for pointing out to me the following quote from Chapter 11, Verse 3, of the "Book of the Hebrews": "By faith we understand that the world was created by the word of God, so that what is seen was made out of things which do not appear."