1964:

Barnes et al. discover the Ω^- ($S = -3, M = 1686 \pm 12$ MeV) as predicted by the "eightfold way" with the mass as given by the Gell-Mann-Okubo mass formula ($M_\Omega = 3M_\Sigma - 2M_\Delta \sim 1683$ MeV).

Puzzles:

None of the known hadrons could be classified according to the fundamental representation of SU(3), i.e. the representation from which all other multiplets can be built: $I_{max} = 1/2, Y = -2/3, 1/3$.

Why do mesons (B=0) only appear as singlet and octet representations of the flavor-SU(3) and baryons (B=1) only as singlets, octets and decimets ?

The flavor-SU(3) classification strongly hinted at the existence of a substructure of hadrons:

Gell-Mann and Zweig introduce the quark model: u, d, s

The quarks u, d, s form a triplet under flavour-SU(3) and are assumed to have the following internal quantum numbers:

	I	I_3	Y	S	B	$Q = I_3 + Y/2$
u	1/2	+1/2	+1/3	0	1/3	2/3
d	1/2	-1/2	+1/3	0	1/3	-1/3
s	0	0	-2/3	-1	1/3	-1/3

Hadrons are now understood as boundstates of two and three quarks: mesons: $q\bar{q}$, baryons: qqq

The product representation of a quark and anti-quark in terms of irreducible parts is $3 \times 3^* = 1 + 8$ and for three quarks it is $3 \times 3 \times 3 = 1 + 8 + 8 + 10$.

Puzzle:

The overall wavefunction of the $J^P = 3/2^+$ baryon resonance Δ^{++} with the three up-quarks being in the ground state is total symmetric

$$\Delta^{++} \sim u(\uparrow)u(\uparrow)u(\uparrow)\Psi(x_1, x_2, x_3)$$

with the space part $\Psi(x_1, x_2, x_3)$ being total symmetric. But a total symmetric wavefunction for particles with spin $1/2$ contradicts the Pauli principle.

1964/65:

Greenberg, Han and Nambu solve this puzzle by increasing the degrees of freedom of the quarks. In the formulation of Gell-Mann (1972) and Fritzsch (1973) a new quark quantum number is introduced, color, so that each quark exists in three different colors: red,green,blue:

Baryons: $1/\sqrt{6}\sum_{c1,c2,c3} q_{f1,c1}q_{f2,c2}q_{f3,c3}\epsilon_{c1c2c3}$

Mesons: $1/\sqrt{3}\sum_{c1,c2} q_{f1,c1}\bar{q}_{f2,c2}\delta_{c1c2}$

with the total antisymmetric tensor $\epsilon_{123} = +1, \epsilon_{213} = -1 \ldots$.