The chemical composition of Earth's atmosphere II: the big two

Mole %	*Name*	*Chemical formula*	*Residence Time*
78.084	**Nitrogen**	**N_2**	**10^6-10^7 years**
20.948	**Oxygen**	**O_2**	**3000-10,000 years**
0.934	Argon	Ar	Forever
0.004 - 4	Water vapor	H_2O	~10 days
0.0385 (385 ppm)	Carbon dioxide	CO_2	2-10 years
0.001818 (18.18 ppm)	Neon	Ne	Forever
0.000524 (5.24 ppm)	Helium	He	~10^6 years
0.00017 (1.7 ppm)	Methane	CH_4	2-10 years
0.000114 (1.14 ppm)	Krypton	Kr	Forever
0.00005 - 0.0010	Stratospheric ozone	O_3	
0.000055 (0.55 ppm)	Hydrogen	H_2	4-8 years
0.000033 (0.33 ppm)	Nitrous oxide	N_2O	5-200 years
0.0000050 - 0.0000200	Carbon monoxide	CO	60-200 days
0.0000087 (87 ppb)	Xenon	Xe	Forever
0.0000010 - 0.0000500	Tropospheric ozone	O_3	
0.0000005 - 0.0000020	NMHC	C_xH_y	
0.0000000540 (540 ppt)	CFC12	CF_2Cl_2	>80 years
0.00000005 (500 ppt)	Carbonyl sulfide	OCS	~ 2 years
0.0000000265 (265 ppt)	CFC11	$CFCl_3$	~80 years
0.00000001 - 0.000001	Hydrogen peroxide	H_2O_2	1 day
0.00000001 - 0.0000001	Formaldehyde	CH_2O	5-10 days
0.0000000098 (98 ppt)	Carbon tetrachloride	CCl_4	≥ decades
0.0000000065 (65 ppt)	Methylchloroform	CH_3CCl_3	~7 years
0.000000001 - 0.0001	Nitrogen oxides	NO_x	A few days
0.000000001 - 0.0000001	Ammonia	NH_3	A few days
0.000000001 - 0.0000001	Sulfur dioxide	SO_2	hours to weeks
0.000000001 - 0.00000001	Dimethyl sulfide	CH_3SCH_3	<1 day
0.0000000001 - 0.00000003	Carbon disulfide	CS_2	~40 days
0.0000000005 - 0.00000005	Hydrogen sulfide	H_2S	<5 days
0.0000000002 (2 ppt)	Hydroperoxyl radical	HO_2	
0.000000000005 (0.05 ppt)	Hydroxyl radical	OH	≤ a few seconds

99% of Earth's atmosphere is just two components, N_2 and O_2. They are both so abundant because of biological processes.

N_2 is abundant because denitrifying bacteria in soils and seawater reduce the N of nitrate to produce N_2 (and, to a lesser extent, N_2O). These bacteria are called "denitrifying" from the standpoint of the ecology of nutrients, in that the denitrifying bacteria remove nitrate, commonly a critical nutrient, from ecosystems.

O_2 is abundant because it is produced as a byproduct of photosynthesis. As photosynthehsizers produce organic matter by the reaction

$$6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

they reduce oxidized carbon to make carbohydrate and thus must leave behind O as O_2. The persistence of oxygenic photosynthesis for at least two billion years has produced our modern O_2-rich atmosphere.

Another way to view this is to consider how the ocean-atmosphere would evolve without biology. Inorganic chemical equilibrium would dictate that, under the present atmosphere, seawater would have a nitrate (NO_3^-) concentration ten orders of magnitude (ten billion times) greater than it is. That remarkable disequilbrium is a testimony to the power of Earth's biota to control the chemistry of the exosphere.

Sources: see Part I of this series.