Fig. 23-1. Disorders caused by mutations in genes controlling protein synthesis are shown in blue and disorders caused by mutations in protein-coding genes are shown in red. FBSN, familial bilateral striatal necrosis; LHON, Leber hereditary optic neuropathy; LS, Leigh syndrome; MELAS, mitochondrial encephalomyopathy, lactic acidosis, and stroke-like episodes; MERRF, myoclonus epilepsy and ragged-red fibers; MILS, maternally inherited Leigh syndrome; NARP, neuropathy, ataxia, retinitis pigmentosa; PEO, progressive external ophthalmoplegia.

Fig. 23-2. T1-weighted magnetic resonance (MR) brain images at the level of the lateral ventricles from three subjects, an asymptomatic control (left panel); an oligosymptomatic mutation carrier (middle panel); and a fully symptomatic MELAS patient (right panel). Above each image are 1H-MR spectra of a voxel in the left gray matter (left) and from a voxel in the left lateral ventricle (right). Voxels are represented by red squares. The spectral resonances have been ascribed to: CHO, total choline; CR, total creatine; NAA, N-acetylaspartate; and LAC, lactate. All the spectra have been plotted on the same vertical scale.
Histology of mtDNA-related diseases. Top panels: in normal human muscle, all fibers stain with the succinate dehydrogenase (SDH) and the cytochrome c oxidase (COX) reactions (A and B, respectively). The different intensities correspond to type 1 (darker stains) and type 2 (lighter stains) fibers. Middle and lower panels: in a patient with MERRF due to the m.8344A > G mutation, two ragged-red fibers are evident with the modified Gomori trichrome stain (C); the same fibers appear ragged-blue with the SDH stain (D), are COX-negative (E), and appear blue with combined COX/SDH stain (F).
Fig. 23-3B. **Histology of mtDNA-related diseases. Top panels:** in normal human muscle, all fibers stain with the succinate dehydrogenase (SDH) and the cytochrome c oxidase (COX) reactions (A and B, respectively). The different intensities correspond to type 1 (darker stains) and type 2 (lighter stains) fibers. **Middle and lower panels:** in a patient with MERRF due to the m.8344A > G mutation, two ragged-red fibers are evident with the modified Gomori trichrome stain (C); the same fibers appear ragged-blue with the SDH stain (D), are COX-negative (E), and appear blue with combined COX/SDH stain (F).
Fig. 23-3C. **Histology of mtDNA-related diseases. Top panels:** in normal human muscle, all fibers stain with the succinate dehydrogenase (SDH) and the cytochrome c oxidase (COX) reactions (A and B, respectively). The different intensities correspond to type 1 (darker stains) and type 2 (lighter stains) fibers. **Middle and lower panels:** in a patient with MERRF due to the m.8344A > G mutation, two ragged-red fibers are evident with the modified Gomori trichrome stain (C); the same fibers appear ragged-blue with the SDH stain (D), are COX-negative (E), and appear blue with combined COX/SDH stain (F).
Fig. 23-3D. Histology of mtDNA-related diseases. Top panels: in normal human muscle, all fibers stain with the succinate dehydrogenase (SDH) and the cytochrome c oxidase (COX) reactions (A and B, respectively). The different intensities correspond to type 1 (darker stains) and type 2 (lighter stains) fibers. Middle and lower panels: in a patient with MERRF due to the m.8344A > G mutation, two ragged-red fibers are evident with the modified Gomori trichrome stain (C); the same fibers appear ragged-blue with the SDH stain (D), are COX-negative (E), and appear blue with combined COX/SDH stain (F).
Fig. 23-3E. **Histology of mtDNA-related diseases.** Top panels: in normal human muscle, all fibers stain with the succinate dehydrogenase (SDH) and the cytochrome c oxidase (COX) reactions (A and B, respectively). The different intensities correspond to type 1 (darker stains) and type 2 (lighter stains) fibers. **Middle and lower panels:** in a patient with MERRF due to the m.8344A > G mutation, two ragged-red fibers are evident with the modified Gomori trichrome stain (C); the same fibers appear ragged-blue with the SDH stain (D), are COX-negative (E), and appear blue with combined COX/SDH stain (F).
Fig. 23-3F. **Histology of mtDNA-related diseases. Top panels:** in normal human muscle, all fibers stain with the succinate dehydrogenase (SDH) and the cytochrome c oxidase (COX) reactions (A and B, respectively). The different intensities correspond to type 1 (darker stains) and type 2 (lighter stains) fibers. **Middle and lower panels:** in a patient with MERRF due to the m.8344A > G mutation, two ragged-red fibers are evident with the modified Gomori trichrome stain (C); the same fibers appear ragged-blue with the SDH stain (D), are COX-negative (E), and appear blue with combined COX/SDH stain (F).
Fig. 23-4. **Genes and corresponding gene products are similarly color-coded.** ND denote the subunits of NADH-coenzyme Q oxidoreductase (complex I); cyt b, cytochrome b; subunits of cytochrome c oxidase are labeled CO in the mtDNA scheme and COX in the respiratory chain rendition; A6 and A8 indicate subunits 6 and 8 of ATP synthase. The 22 tRNA genes are denoted by one-letter amino acid nomenclature; 12S and 16S denote ribosomal RNAs (rRNAs). OH and OL are the origins of heavy- and light-chain replication; HSP and LSP are the promoters of heavy- and light-stranded transcription. ADP, adenosine diphosphate; ATP, adenosine triphosphate; IMM, inner mitochondrial membrane; IMS, intermembrane space; MAT, mitochondrial matrix.