Table 17.2. Normal Oxidation-Reduction Potentials of Some Biologically Important Systems at pH 7.0

SYSTEM	E'_0	T IN °C.
Ketoglutarate ⇌ succinate + CO_2 + $2H^+$ + 2e	−0.68	—‡
Ferredoxin	−0.432	—§
Formate ⇌ CO_2 + H_2	−0.420	38
H_2 ⇌ $2H^+$ + 2e	−0.414	25
NADH + H^+ ⇌ NAD^+ + $2H^+$ + 2e	−0.317	30†
NADPH + H^+ ⇌ $NADP^+$ + $2H^+$ + 2e	−0.316	30†
Horseradish oxidase	−0.27	—†
$FADH_2$ ⇌ FAD + $2H^+$ + 2e	−0.219	30†
$FMNH_2$ ⇌ FMM + $2H^+$ + 2e	−0.219	30†
Lactate ⇌ pyruvate + $2H^+$ + 2e	−0.180	35
Malate ⇌ oxaloacetate + $2H^+$ + 2e	−0.102	37
Reduced flavin enzyme ⇌ flavin enzyme + $2H^+$ + 2e	−0.063	38
Luciferin* ⇌ oxyluciferin + $2H^+$ + 2e	−0.050	?*
Ferrocytochrome B ⇌ ferricytochrome B + e	−0.04	25
Succinate ⇌ fumarate + $2H^+$ + 2e	−0.015	30
Decarboxylase	+0.19	—†
Ferrocytochrome C ⇌ ferricytochrome C + e	+0.26	25
Ferrocytochrome A ⇌ ferricytochrome A + e	+0.29	25
Ferrocytochrome A_3 ⇌ ferricytochrome A_3 + e	?	—‡
H_2O ⇌ ½O_2 + $2H^+$ + 2e	+0.815	25

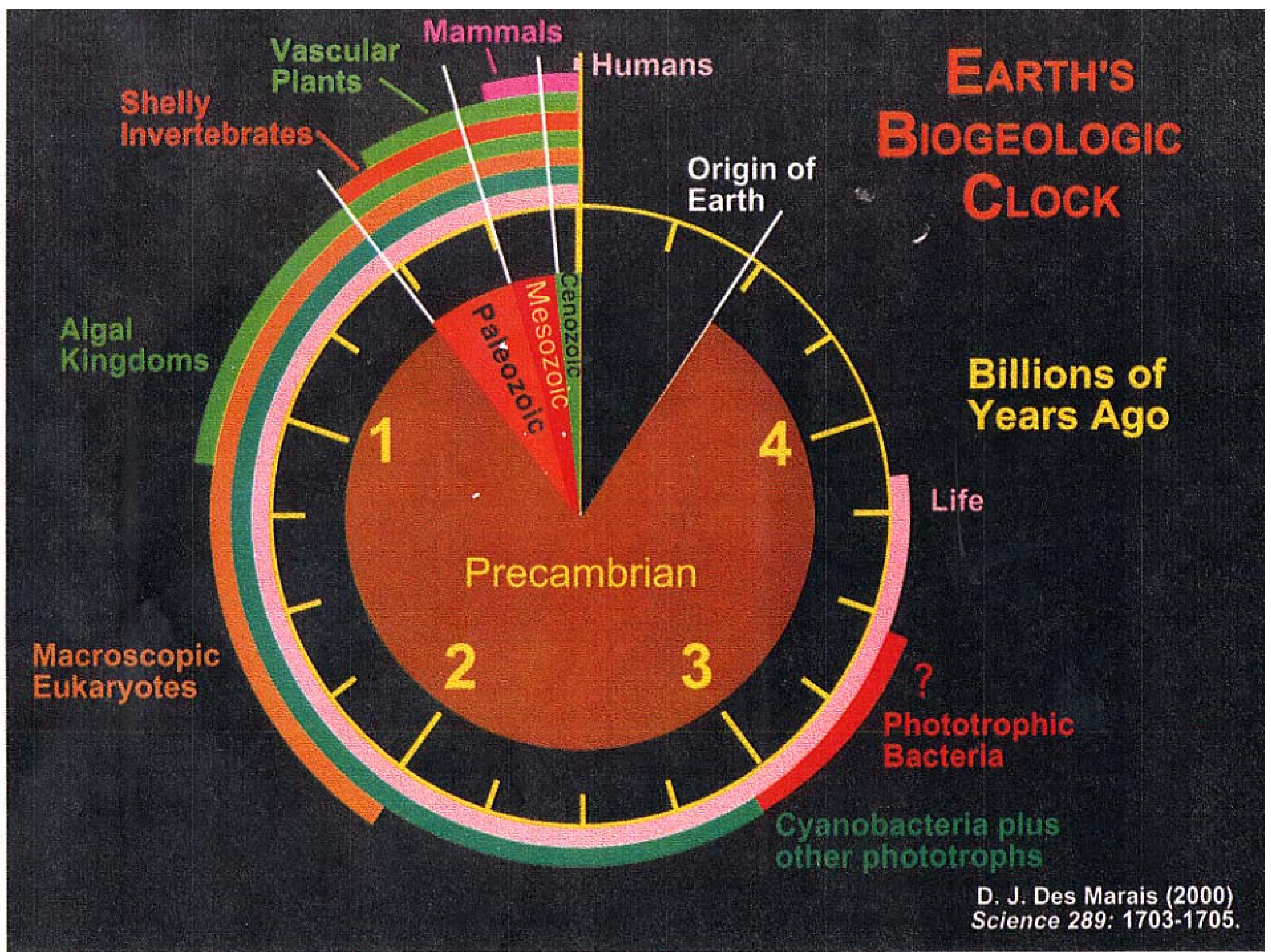
Data from Goddard, 1945. Potentials in all cases are at or near neutrality.

* From McElroy and Strehler, 1954: Bact. Rev. *18*.

† From Clark, 1960.

‡ From Goddard and Bonner, 1960: *In* Plant Physiology, a Treatise. Steward, ed. Academic Press, New York. Goddard and Bonner give the NADPH/$NADP^+$ system as −0.324, and NADH/NAD^+ as −0.320.

§ From Tagawa and Arnon, 1962: Nature *195*:537–543. The value cited is for spinach ferredoxin.



EARTH'S BIOGEOLOGIC CLOCK
Mammals
Humans
Vascular Plants
Shelly Invertebrates
Origin of Earth
Algal Kingdoms
Paleozoic
Mesozoic
Cenozoic
Billions of Years Ago
1
4
Life
Precambrian
2
3
Macroscopic Eukaryotes
?
Phototrophic Bacteria
Cyanobacteria plus other phototrophs
D. J. Des Marais (2000)
Science 289: 1703-1705.

Carbon Pools in the Major Reservoirs on Earth

Table 5.1 Carbon pools in the major reservoirs on Earth

Pools	Quantity ($\times 10^{15}$ g)
Atmosphere	720
Oceans	38,400
Total inorganic	37,400
Surface layer	670
Deep layer	36,730
Total organic	1,000
Lithosphere	
Sedimentary carbonates	>60,000,000
Kerogens	15,000,000
Terrestrial biosphere (total)	2,000
Living biomass	600–1,000
Dead biomass	1,200
Aquatic biosphere	1–2
Fossil fuels	4,130
Coal	3,510
Oil	230
Gas	140
Other (peat)	250

From: Falkowski & Raven. Aquatic Photosynthesis. p. 130 (1997)

REDOX REACTIONS ARE COUPLED ON

MICROSCOPIC SCALES

General Reaction $\longrightarrow$

$$A(ox) + n\,(e^-) \qquad A(red)$$

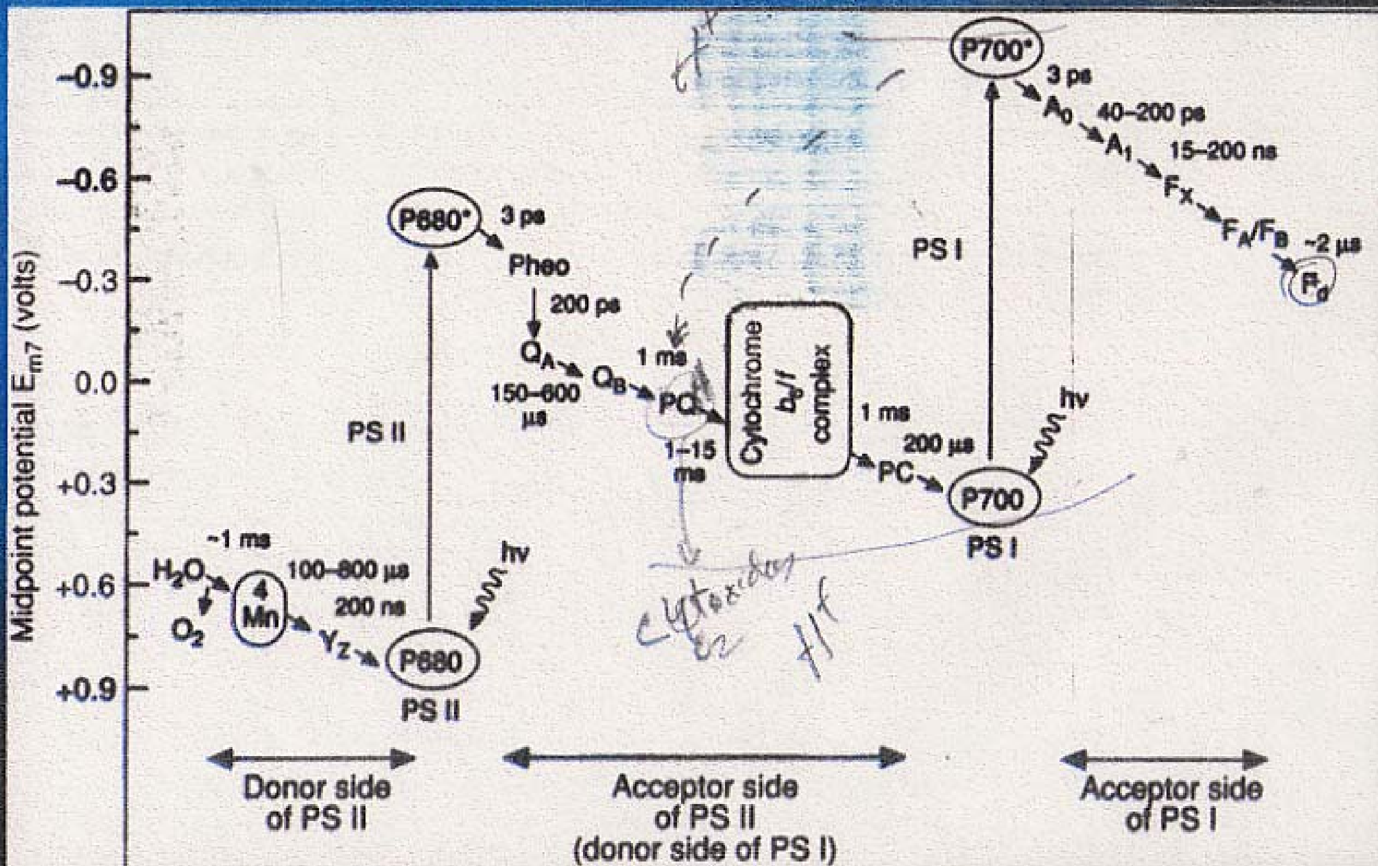
$$B(red) - n(e^-) \longrightarrow B(ox)$$

Photosynthesis

$$2H_2O + \text{light} \longrightarrow 4H^+ + 4e^- + O_2$$

$$CO_2 + 4H^+ + 4e^- \longrightarrow (CH_2O) + H_2O$$

Oxygenic Photosynthetic Electron Transport



From: Falkowski & Raven. Aquatic Photosynthesis. (1997)

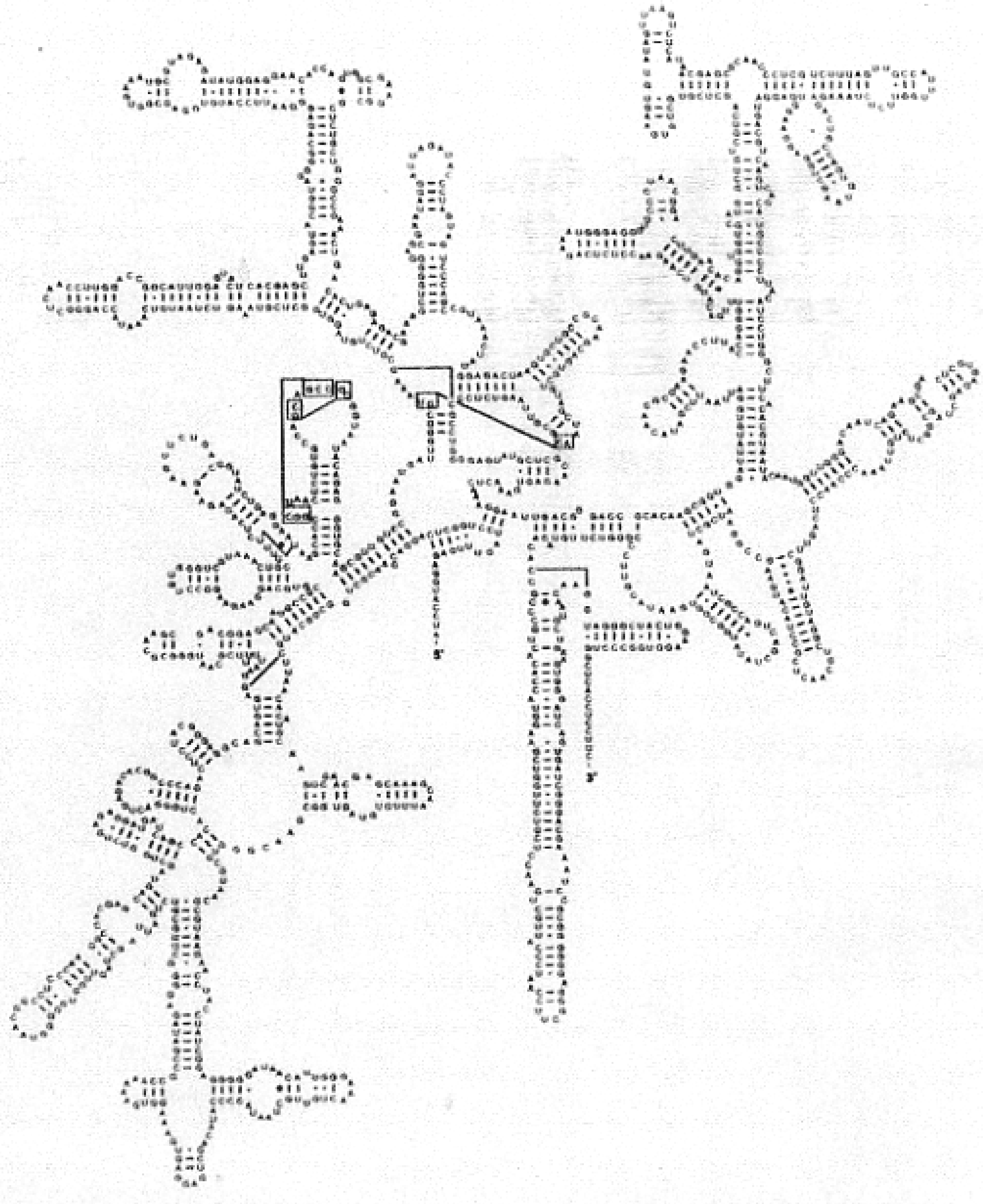
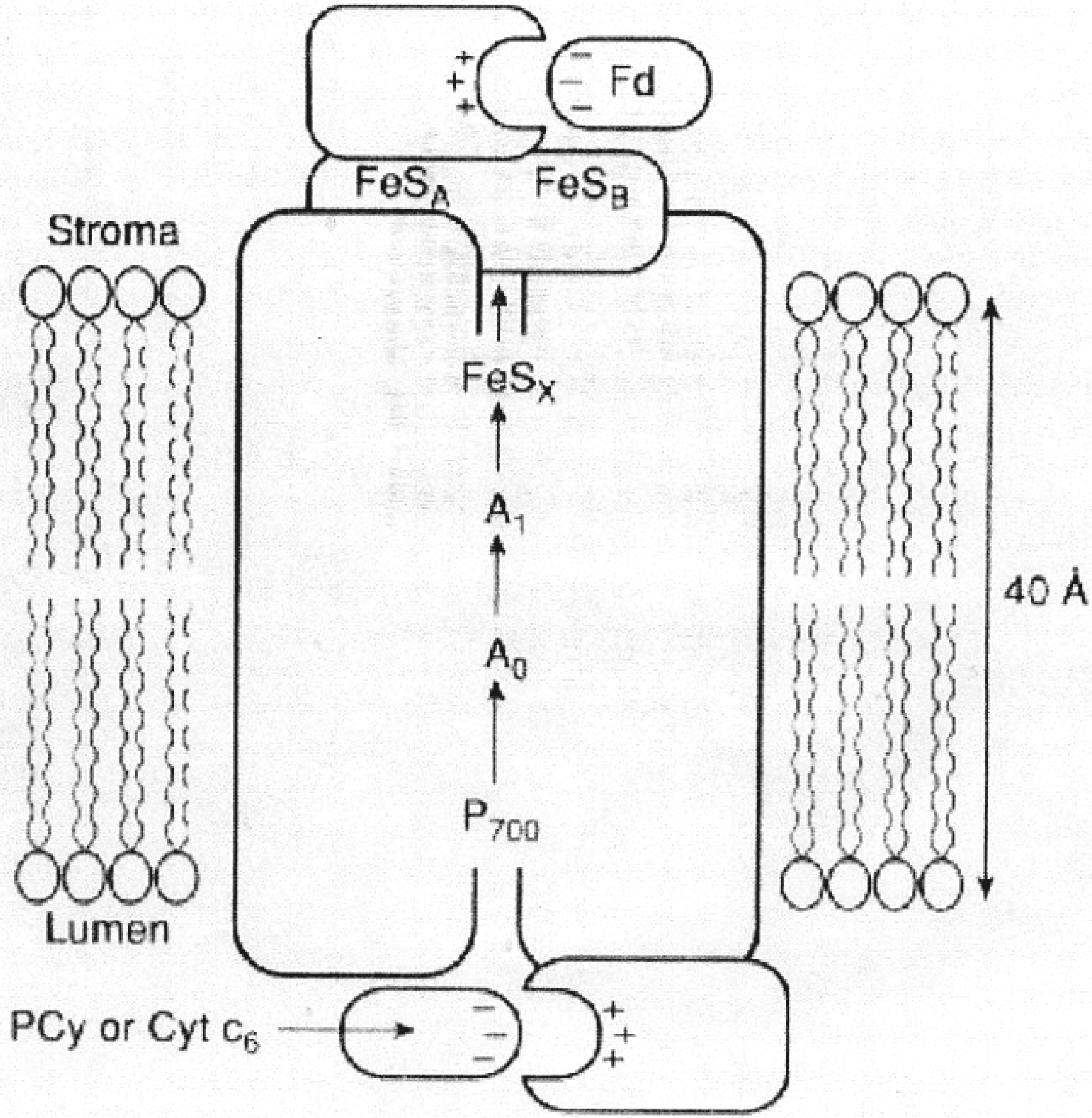


Figure 1.7 The secondary structure of the small subunit (16S) rRNA from *Chlamydomonas reinhardtii*. The structure is inferred from homology with known structures in yeast and prokaryotes. Hollow circles and unpaired regions represent areas of generally higher variability between organisms.



Fd
FeS$_A$
FeS$_B$
Stroma
FeS$_X$
A$_1$
A$_0$
P$_{700}$
40 Å
Lumen
PCy or Cyt c$_6$

The Nernst Equation

$$[A_{ox}] + n\ [e^-] + m[H^+] \longrightarrow [A_{red}]$$

where *m* is the number of protons involved in the reduction of A_{ox}.

The redox potential for this reaction can be calculated by:

$$E = E_{m7} + 59/n \log [A_{red}]/[A_{ox}][H^+]^m$$

which can be rewritten as:

$$E = E_{m7} + 59/n \log ([A_{red}]/[A_{ox}]) + 59(m/n)pH$$