2

Information and Function

2.1 Information and Construction

If we want to build a low-cost computer, we buy components and build it. Three essential features are involved: (i) instructions for how to assemble, (ii) parts, and (iii) assembler. In a biological system, these components are also present, but the situation is more complex: The assembler must be part of the system, and the system must be self-reproducing. The structure of such a system is schematically shown in Fig. 2.1.

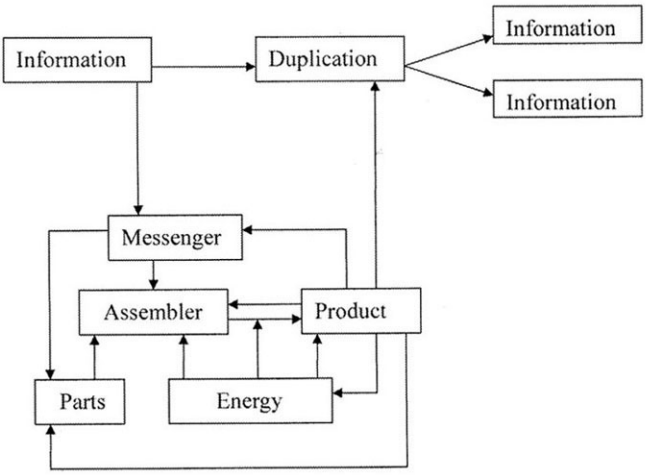

Fig. 2.1. Self-reproducing system.

H. Frauenfelder, *The Physics of Proteins*, Biological and Medical Physics, Biomedical Engineering, DOI 10.1007/978-1-4419-1044-8_2,

The stored information directs the assembly of new parts. These are needed in the reading and transfer of the information and in the assembly. The entire system thus involves a very large number of components and multiple feedback loops.

2.2 Information Content

Since information storage and transfer are crucial in all life processes, a brief description of some relevant concepts is in order. Consider a system where g, the *basis*, gives the number of different "letters" and n, the *digits*, the number of units of the information carrier (number of letters in a word). The *information capacity* $N_{\lambda\nu}$ is given by

$$N_{\lambda\nu} = \lambda^{\nu}. \tag{2.1}$$

The *information content* is defined by

$$I = \ln N_{\lambda\nu} / \ln 2 = \nu \ln \lambda / \ln 2. \tag{2.2}$$

The unit of I is 1 *bit* (binary digit). As an example, consider four-letter words in the English language, proteins with 100 building blocks, and nucleic acids with 10^7 units. The English language has 26 letters, proteins are built from 20 amino acids, and nucleic acids have 4 building blocks. We therefore have the values of $N_{\lambda\nu}$ and I given in Table 2.1. The essential components of the system as it occurs in living things are shown in Fig. 2.2. The actual arrangement is far more complex and involves many feedback loops. The basic principles, however, are contained in Fig. 2.2.

Table 2.1. Information Capacity and Content.

System	Basis λ	Digits ν	Information Capacity $N_{\lambda\nu}$	Information Content I (bits)
English words	26	4	26^4	18.8
Protein	20	100	20^{100}	432
Nucleic acid	4	10^7	4^{107}	2×10^7

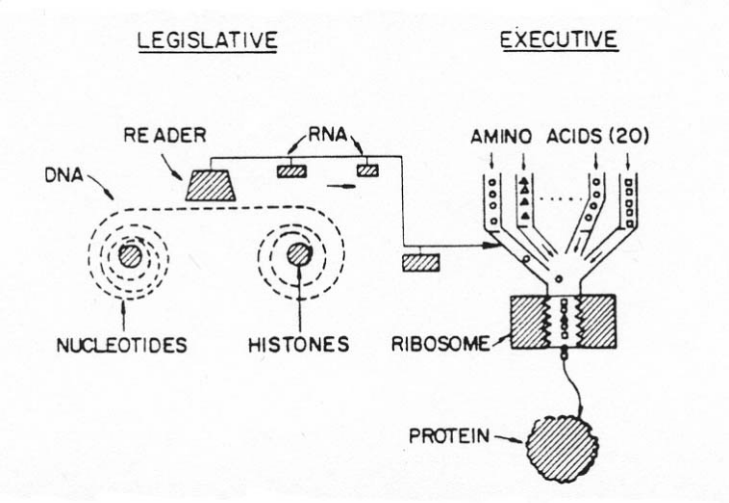

Fig. 2.2. Biomolecules: Legislative and executive. Nucleic acids store and transport information and direct the assembly of proteins. Proteins, assembled from amino acids (AA), are the machines of life. The information is stored on DNA and transported by RNA.

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The Physics of Proteins
An Introduction to Biological Physics and Molecular Biophysics
Frauenfelder, H. - Chan, S.S.; Chan, W.S. (Eds.)
2010, XVI, 448 p. 221 illus., 7 illus. in color., Hardcover
ISBN: 978-1-4419-1043-1