Subject:
In textbooks on biology and related areas one may find statements about negative values of the entropy, for instance: “Living systems steadily produce positive entropy. In order to escape a decomposition into the thermodynamical equilibrium, these systems need a continuous supply of negative entropy. The only abundant source of negative entropy, which is available to living systems, is the excitation energy of the pigments. The excitation is carried out by photons. The only natural source for photons is the sun.” Sometimes negative entropy is also called negentropy, and negentropy, so it is said, is identical with Shannon’s information.

Deficiencies:
Such statements partly only offend physical practice, but partly they are incorrect.
1. Whenever the value of an extensive quantity $X$ increases in system $A$ and decreases in system $B$, because there is a current of $X$ between $A$ and $B$, there are two possibilities to bring the process into words: Either one says that there is a current of positive $X$ from $B$ to $A$, or one says that there is a current of negative $X$ from $A$ to $B$. The theory (more exactly: the continuity equation) does not distinguish between these two ways of speaking. Only in the case that a velocity can be unambiguously attributed to the current, i.e. the current density $j_X$ can be expressed by a density $\rho_X$ and a velocity $v$

\[ j_X = \rho_X \cdot v, \]

such a distinction may be justified. If the density $\rho_X$ is negative, it can be argued that it is convenient to say that negative $X$ is flowing from $A$ to $B$. If $\rho_X$ is positive, one would prefer to say that positive $X$ flows from $B$ to $A$. Even so, this distinction is not necessary.

However, if the quantity $X$ can admit only positive values in principle, as it is the case for mass or entropy, then it is certainly not convenient to say that negative $X$ is flowing from $A$ to $B$, since this kind of wording suggests that a negative density of mass or entropy exists.

When speaking about negative entropy, as in our citation, one clearly pursues an objective: One intends to attribute the merit for the fact that the entropy of the living system does not increase to the sun. And now comes the mistake: Even if one defies that there is no negative entropy, one should admit that the flow of the hypothetic negative entropy takes the same path as the positive entropy that is actually flowing, although in the opposite direction. Now, since the positive entropy is flowing into the environment, one might at best say, that negative entropy flows from the environment into the living system. Thus the claim that negative entropy comes from the sun, is simply not correct. Since the subject is rather complex, the fact has gone unnoticed.
To further illustrate the problem let us apply the statement to a system which is more transparent: the heating wire of an electric heater. The normal and correct description of the entropy balance would be as follows: In the wire entropy is produced. This flows out into the environment. A statement that is analogue to the one of our citation would say: With the electric energy negative entropy is supplied to the wire. This entropy is compensated by that entropy which is produced in the wire. Obviously this statement is not correct.

2. If negative entropy (or negentropy) is identified with information (amount of data) then one is making a mistake of another kind. Let us first remind that entropy $S$ and information $H$ are calculated by means of the same statistical formula:

$$ S = -k \sum_i p_i \ln p_i \quad \quad H = -f \sum_i p_i \ln p_i $$

Here $p_i$ is the probability of the system to be in the microstate with the number $i$. $k$ is the Boltzmann constant and $f$ is a constant factor that is chosen in such a way that the unit of $H$ is the bit. Thus, the values of both quantities are determined by the same procedure, what means that the two quantities are identical. The entropy of a system and the information stored in its microstate are, apart from a constant factor the same physical quantity.

Now, often the following awkwardness can be observed. We consider a system A. Instead of saying that the information $H$ is stored in A it is said that $H$ is the information that the observer is missing. And one goes yet one step further: One says that the observer has negentropy $N$ with:

$$ N = -H. $$

Instead of attributing the value to the system for which it was calculated or measured, one takes the negative of this value and attributes it to the complement of the system, i.e. to the environment or to the observer who is a part of the environment. It is as if you described the mass $m$ of a body saying that the environment has the “negmass” $n = -m$. Such a procedure can certainly be kept up for a while, but there is no doubt that it is extremely uncomfortable.

**Origin:**

Negative entropy has a long tradition. Peter Guthrie Tait, a thermodanymicist and friend of Lord Kelvin, already has thought of introducing a negative entropy but prescinded from it [1]: “It is very desirable to have a word to express the Availability for work of the heat in a given magazine; a term for that possession, the waste of which is called Dissipation. Unfortunately the excellent word Entropy, which Clausius has introduced in this connection, is applied by him to the negative of the idea we most naturally wish to express.”

Negative entropy was definitely introduced into physics by Schrödinger. In his book “What is life?” from 1944, which is devoid of any mathematics, he writes: “What is this precious something in our food which saves us from death? This is easy to answer. Every process, every event, everything that happens – you can call it as you want – in short, everything that goes on in nature, means an increase of the entropy of that part of the world in which the process takes place. Thus a living organism continually increases its entropy – or if one prefers, it produces positive entropy – and thus strives for the dangerous state of maximum entropy, which means death. It can
only keep away, i.e. it can live only, by constantly extracting negative entropy from its environment, – which actually is something very positive, as we shall see soon. What is nourishing an organism is negative entropy. Or, to put it somewhat less paradoxical, it is the essence of the metabolism that the organism succeeds in getting rid of the entropy which it has to produce as long as it lives."

These statements of Schrödinger provoked the objection of his colleagues. Schrödinger defended himself, but somewhat half-heartedly.

The term negentropy had been introduced in 1956 by Brillouin [2]. At that time there appeared several publications about the relation between the thermodynamical quantity entropy and the quantity *information*, introduced shortly before by Shannon. Brillouin attached so much importance to this idea that he called it the “negentropy principle of information”. As mentioned earlier, the inconvenience of his proposal is that he attributes the quantity information to the observer or experimenter and not to the system for which it is calculated.

One reason of this inconvenient assignment may be the name that is usually given to the quantity: information.

Suppose for a computer data store (of for the microstates of a perfect gas) it has been calculated: \( H = x \ \text{MByte}. \) When calling the quantity \( H \) information it seems logical to say: “I lack the information \( x \ \text{MByte} \) about the data store (or about the perfect gas).” If on the contrary, \( H \) would be called *amount of data*, then another wording seems more appropriate: “The amount of data within the data store or in the perfect gas is \( x \ \text{MByte}. \)” Thus when using the term amount of data the values of the quantity are correctly attributed to the data store or to the gas.

**Disposal:**

1. There is no need for a negative entropy. Everything is clearer when one is content with the positive entropy.

2. Attribute the quantity \( H \) to the data store (or the thermodynamic microstates) and not to the observer. Call it *amount of data*.

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