

# A Series of Unfortunate Misprints

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## 1. The Typographic Error

The typographic error  
Is a slippery thing and sly,  
You can hunt till you are dizzy  
But it somehow will get by.

Till the forms are off the presses,  
It is strange how still it keeps;  
It shrinks down in a corner  
And it never stirs or peeps.

The typographic error,  
Too small for human eyes,  
Till the ink is on the paper,  
When it grows to mountain size.

The boss he stares with horror,  
Then he grabs his hair and groans;  
The copy reader drops his head  
Upon his hands and moans.

The remainder of the issue  
May be as clean as clean can be,  
But that typographic error  
Is the only thing you see.

— Anonymous

## 2. Unfortunate Misprints in *Life Itself*

There are numerous misprints in Robert Rosen's *Life Itself* — I noted over one hundred in my marked-up copy. Most of the errors are minor and are of a typographic nature. There are, however, several serious ones. These misprints are just what they are, misprints rather than scientific errors, so they do not affect the validity of the logical arguments. But they can certainly cause difficulties for a reader studying *Life Itself* “in pedantic detail”.

In this short note, I shall indicate the corrections of a few of these serious errors. My corrections

are marked **in red** in the passages that I quote from *Life Itself* (hereafter denoted LI). I shall also give a brief explanation of the respective semantics.

### 3. Colour Blindness (LI, p.244)

#### 10A. The Answer

The answer we propose is now this: *a material system is an organism if, and only if, it is closed to efficient causation*. That is, if  $f$  is any component of such a system, the question “why  $f$ ?” has an answer within the system, which corresponds to the category of efficient cause of  $f$ . In terms of the graphs we have been using, every component must (1) initiate a **solid-headed** arrow, since it is a component, and (2) terminate a **hollow-headed** arrow. We claim that everything else about organisms, everything studied in biology by biologists, and much else besides, arises from and devolves upon this property.

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The red/green description of the arrows is obviously a remnant from some earlier draft when the diagrams were to be printed in colour. That in itself is a simple misprint. But the properties (1) and (2) that characterize “closed to efficient causation” are very important concepts, so the correct translations red=solid-headed and green=hollow-headed are crucial.

The solid/hollow-headed arrow symbolism was first introduced on LI p.219. Its form evolved a few times, and settled on this representation (LI [9E.4] and [10C.1] )



of the simple mapping

$$f : A \rightarrow B . \tag{4}$$

Sometimes it is useful to trace the path of an element as it is mapped. If  $a \in A$  and  $b = f(a) \in B$  , I use the “maps to” arrow (note the short vertical line at the tail of the arrow) and write

$$f : a \mapsto b . \tag{5}$$

The hollow-headed arrow in diagram (3) denotes the *flow* from input [afferent; material cause] *a* in *A* to output [efferent; product] *b* in *B*, and the solid-headed arrow denotes the induction or generation of this flow by the *processor* [efficient cause] *f*. When (unnecessarily) interpreted in completely mechanistic terms, the flow is the *software*, and the processor is the *hardware*. The efficient cause and output relationship may be called “*f* entails *b*” (LI Sections 5H and 9D).

Property (1) of the graph of a relational model of an organism, initiation of a solid-headed arrow, is the requirement that every component is an efficient cause. Property (2), termination of a hollow-headed arrow, is the “closure” part, the requirement that each efficient cause is itself entailed. Note the “every component” part of the characterization is slightly inaccurate. It should be modified to “every component except the initial input *A*”. But of course in Section 10A, *A* has not yet been defined. I shall have more to say on this below when I discuss Section 10C.

Recall (LI p.230) that the defining feature of a *mechanism* is *the absence of certain kinds of paths* in the graph of its inferential entailment pattern:

*If a vertex in this graph originates a solid-head arrow, it cannot terminate a hollow-head arrow.*

This is, of course, precisely the negation of properties (1)+(2), thus making the categories of mechanisms and organisms complementary to each other. In Section 9G, Rosen concluded that

...certain modes of entailment are not available in a mechanism. In particular: *there can be no closed path of efficient causation in a mechanism*. In terms of the graphs we have been using in the preceding sections, the conclusion is that *there is no cycle that contains all the solid-head arrows*.

Thus for a relational diagram representing the impredicative entailment structure of an organism, a graph that satisfies properties (1)+(2), the consequence is that *there exists a cycle that contains all the solid-headed arrows*. The mathematical subject here is graph theory. A cycle that contains all the solid-headed arrows corresponds to the graph-theoretic concept of *Eulerian circuit*, with the property called *transversability*.

#### 4. Not a Vertex (LI, pp.250–251)

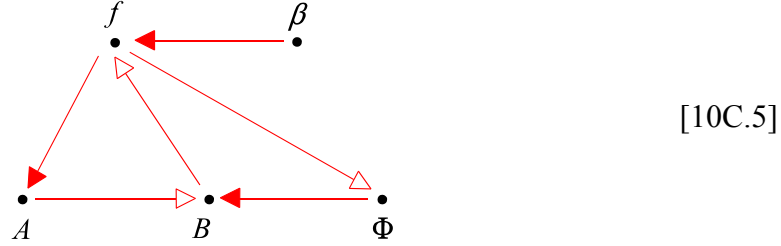
### 10C. Relational Models of Organisms

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But now  $\Phi$  is unentailed, as we have seen; we do not yet have enough entailment in the system to answer the question “why  $\Phi$ ?” Intuitively, if we did have it, then we would thereby embody *another function*, in addition to the two (namely, metabolism and repair), which the diagram already

manifests. Let us give a name to this new function, which would entail repair; let us call it *replication*.

A simple-minded iteration of the preceding argument would lead us to throw a new vertex  $\beta$ , embodying the new replication function, into the graph and draw the appropriate arrows. Again assuming that the domain of  $\beta$  is to be identified with the range of  $\Phi$ , we get



or, in abbreviated form,

$$A \xrightarrow{f} B \xrightarrow{\Phi} H(A, B) \xrightarrow{\beta} H(B, H(A, B)).$$

But once again, this seems to gain us nothing, since the new vertex  $\beta$ , representing the new replication function, is unentailed.

The point of departure for everything I have said in the present volume in fact arose from my discovery, a very long time ago (in 1957, to be exact) that  $\beta$  was not a *new* vertex. In effect, the function of replication could already be represented simply by throwing more arrows, more entailment, into the diagram we already had. In other words, the *function* of replication could be, under certain formal circumstances, already entailed by the two prior functions of metabolism and repair.

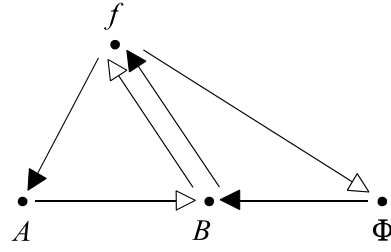
I have since repeated this formal argument many times in previous work and need not repeat it here. In brief, it involves two steps: first, to regard an element  $b$  in  $B$  as itself a processor; as a mapping  $\hat{b}$  defined by

$$\hat{b}(\Phi) = \Phi(b).$$

This is not yet the mapping we really want; what we want is

$$\hat{b}^{-1} \equiv \beta$$

*if it exists*. Readers can readily establish for themselves, or go back to the earlier published versions of the argument, that the condition for invertibility of  $\hat{b}$  is really a condition on  $H(A, B)$ . If that condition (which is restrictive, but not unduly so) is in fact satisfied, then our diagram becomes



[10C.6]

In this graph, every function is indeed entailed by another function in the graph itself. As far as entailment is concerned, the environment is out of the picture completely, except for the initial input  $A$ .

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The function  $\hat{b}$  is invertible if it is monomorphic (i.e. one-to-one); viz. for every pair of repair maps  $\Phi_1, \Phi_2 \in H(B, H(A, B))$ ,

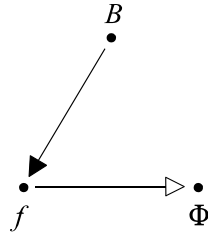
$$\hat{b}(\Phi_1) = \hat{b}(\Phi_2) \Rightarrow \Phi_1 = \Phi_2 ; \quad (6)$$

i.e.

$$\Phi_1(b) = \Phi_2(b) \Rightarrow \Phi_1 = \Phi_2 . \quad (7)$$

This implication (7) is a condition on the repair maps  $\Phi \in H(B, H(A, B))$ : if two repair maps agree at  $b$ , then they must agree everywhere. In other words, a repair map  $\Phi$  [gene] is uniquely determined by its one value  $\Phi(b) \in H(A, B)$  [enzyme]. This result may be regarded as the abstract version of the *one-gene-one-enzyme hypothesis*. These are essentially the “stringent but not prohibitively strong conditions” required to make the inverse evaluation map a replication map with nothing but the ingredients of metabolism and repair.

There is a bit of notational inconsistency in the relational diagrams. The map



(8)

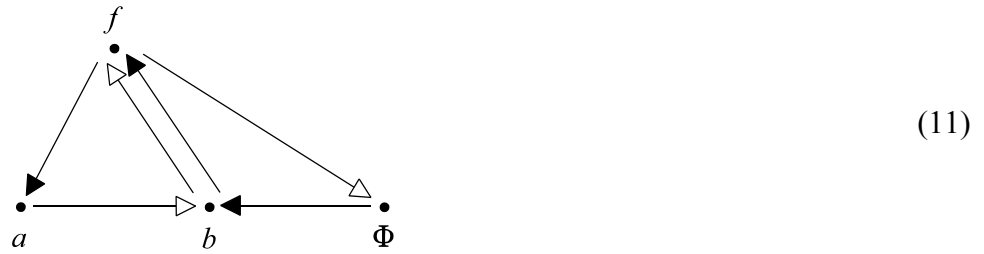
in [10C.6] incorrectly has a set initiating a solid-headed arrow. The efficient cause, the initiating vertex of a solid-headed arrow, has to be an element, not a set (when the object is a single map rather than a family of maps). On the other hand, the domain and codomain, the terminating vertices of the solid-headed and hollow-headed arrows respectively, are established in (3) as sets, not elements. To overcome this, instead of the “morphism : domain  $\rightarrow$  codomain” version of the map (4), I use the element-chasing version (5), and the corresponding relational diagram changes from (3) to



Similarly, diagram (8) may be rewritten as



Then [10C.6] may be replaced by its element-chasing version



The fact that  $\beta = \hat{b}^{-1}$  means  $\beta$  is uniquely determined by  $b$  ; the efficient cause (processor)

$$\beta \longrightarrow f \tag{12}$$

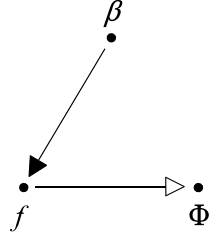
in [10C.5] may, therefore, be “internalized” into (or “replaced by the isomorphic copy”)

$$b \longrightarrow f \tag{13}$$

in (11) (or the slightly ambiguous

$$B \longrightarrow f \tag{14}$$

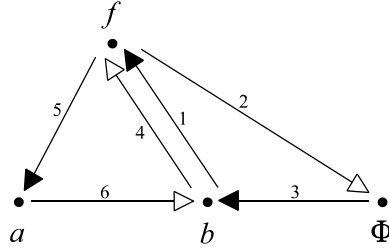
in [10C.6] ). So the relational diagram of replication may change from



(15)

in [10C.5] to form (10) (or the slightly ambiguous form (8)). This is why “ $\beta$  [is] not a *new* vertex” — it is completely determined, and may be replaced, by the *existing* vertex  $b$ . Thus the efficient cause of the replication map is entailed within, closing the path. Note that metabolism is “ $f$  entails  $b$ ”, repair is “ $\Phi$  entails  $f$ ”, and replication is “ $b$  entails  $\Phi$ ”; whence the hierarchical cycle  $(f, \Phi, b)$ .

The following is diagram (11) with all the arrows labelled:



(16)

The “cycle that contains all the solid-headed arrows” in this (M,R)-system is the Eulerian circuit (1,2,3,4,5,6). Note also that every component, except the initial input ( $A$  in [10C.6] and  $a$  in (11) and (16)), satisfies the requisite arrow-incidence properties (1)+(2) discussed in the previous section.

## 5. A Completely Different Situation (LI p.200)

### 7F. Simulations and Models

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Since this distinction between modeling and simulation is so important, I shall describe it in a number of other terminologies. Let me first speak of it in terms of what happens to entailment. To avoid confusion with our earlier discussions, I denote the map to be simulated by  $\varphi : X \rightarrow Y$ . This, as we know, amounts to the entailment

$$\varphi \Rightarrow (x \Rightarrow \varphi(x)) . \quad [7F.1]$$

A modeling relation preserves this entailment:

$$\alpha(\varphi) \Rightarrow ( \alpha(x) \Rightarrow \alpha(\varphi(x)) ) \quad [7F.2]$$

where  $\alpha$  is the encoding arrow ②. In each case,  $\varphi$  and its model  $\alpha(\varphi)$  are both themselves unentailed.

But in a simulation  $\psi$ , we have a completely different situation: namely,

$$\psi \Rightarrow ( [ \alpha(\varphi), \alpha(x) ] \Rightarrow \alpha(\varphi(x)) ) \quad [7F.3]$$

From this we can see most clearly that, instead of a *congruence* between two different inferential structures  $\varphi$  and  $\psi$ , themselves each unentailed, simulation gives us an *entailment*, by the simulator, of the entailment  $\varphi$  it simulates. In other words, simulation turns  $\varphi$  into an effect, a consequence of the simulator  $\psi$ , which may have no relation to  $\varphi$  at all.

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The entailment arrow  $\Rightarrow$  was first defined in LI Section 5H (p.128). It evolved into a solid-headed / hollow-headed detail (the processor / flow distinction) in Section 9D (p.229). In the latter notation, in each of [7F.1], [7F.2], and [7F.3], the first arrow becomes solid-headed and the second arrow becomes hollow-headed. But for the purpose of the current discussion, the undifferentiated arrow  $\Rightarrow$  will do.

The misprint of [7F.2] is the most unfortunate error in LI. This is because the crux of the argument of Chapter 7, on the contrast between *model* and *simulation*, is the comparison of [7F.2] and [7F.3]. The incorrect form of [7F.2] as printed in LI,

$$\alpha(\varphi \Rightarrow (\alpha(\varphi(x))),$$

makes no sense whatsoever. The two-line form of [7F.3] as printed in LI,

$$\left\{ \begin{array}{l} \psi \Rightarrow \{ [ \alpha(\varphi), \alpha(x) ] \Rightarrow \psi [ \alpha(\varphi), \alpha(x) ] \} , \\ \psi [ \alpha(\varphi), \alpha(x) ] = \alpha(\varphi(x)) \end{array} \right.$$

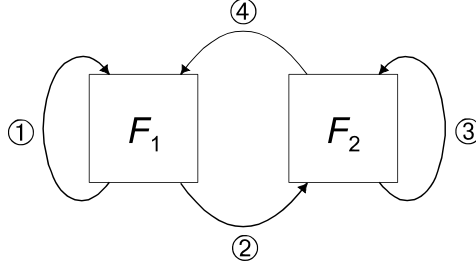
is not wrong; but with  $\psi [ \alpha(\varphi), \alpha(x) ] = \alpha(\varphi(x))$ , it is simpler and clearer to just replace  $\psi [ \alpha(\varphi), \alpha(x) ]$  by  $\alpha(\varphi(x))$  in the first line. So I have combined the two lines into one in the red [7F.3] above.

With my corrected red [7F.2] and [7F.3], “we can see most clearly” that the entailment patterns



of model and simulation are different. But perhaps a few words on why [7F.2] and [7F.3] take on their respective forms are in order.

Figure 7F.1 in LI



shows the modeling relation *as manifested between two formalisms*. With  $\alpha$  as the encoding arrow ② (whence  $\alpha^{-1}$  is the decoding arrow ④), the map to be simulated  $\varphi : X \rightarrow Y$  as the arrow ①, and the simulation  $\psi$  as the arrow ③, this diagram may be rewritten into

$$\begin{array}{ccc}
 Y & \xrightarrow{\alpha} & \alpha(Y) \\
 \uparrow \varphi & & \uparrow \psi \\
 X & \xrightarrow{\alpha} & \alpha(X)
 \end{array} \tag{17}$$

The element-chasing version is

$$\begin{array}{ccc}
 \varphi(x) & \xrightarrow{\alpha} & \alpha(\varphi(x)) \\
 \uparrow \varphi & & \uparrow \psi \\
 x & \xrightarrow{\alpha} & \alpha(x)
 \end{array} \tag{18}$$

The purpose (think final cause!) of a simulation  $\psi$  is to produce the output  $\alpha(\varphi(x))$  from the ingredients of diagram (18). In other words, a simulation  $\psi$  must entail  $\alpha(\varphi(x))$ . One ingredient does not appear explicitly in (18), and that is the map  $\alpha(\varphi)$ , the image under the encoding  $\alpha$  of the map to be simulated  $\varphi$ . A general simulation  $\psi$  is defined by  $\psi[\alpha(\varphi), \alpha(x)] = \alpha(\varphi(x))$  (the entailment [7F.3]). It requires *both*  $\alpha(\varphi)$  and  $\alpha(x)$  as input (material causes) in order to produce  $\alpha(\varphi(x))$ . So in this case, diagram (18) is in fact *not* commutative, because the “extra” ingredient  $\alpha(\varphi)$  is required before  $\alpha(\varphi(x))$  can be generated. For a *simulation*  $\psi$ ,  $\alpha(\varphi)$  is a material cause, rather than the efficient cause.

A true modelling relation maps objects as well as morphisms; a model needs to be more than just

the producer of the output  $\alpha(\varphi(x))$ . So if the simulation  $\psi$  were to actually be a model, we must have  $\psi = \alpha(\varphi)$ , and diagram (18) becomes the *commutative* diagram

$$\begin{array}{ccc}
 \varphi(x) & \xrightarrow{\alpha} & \alpha(\varphi(x)) \\
 \uparrow \varphi & & \uparrow \alpha(\varphi) \\
 x & \xrightarrow{\alpha} & \alpha(x)
 \end{array} \tag{19}$$

In other words, the *model*  $\alpha(\varphi)$  of  $\varphi$  maps thus:  $\alpha(\varphi)(\alpha(x)) = \alpha(\varphi(x))$ . This is the entailment in [7F.2].