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- : (Jonathan Latham)
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  - :
  - :
- 

DNA( )  
 DNA  
 (master molecule)  
 DNA 가  
 . DNA (主) (master controller)가  
 .  
 .  
 .

## 1. DNA

DNA  
 (Kary Mullis) DNA “ ” “

”(the big one) . DNA  
(James Watson) □DNA: □(DNA: The Secret of Life) “  
” DNA .

MIT < >(Broad  
Institute) (Eric Lander) □DNA: □  
“ ” - (Mary-  
Claire King) “ DNA • • •  
• ” .

DNA 가  
□(Life) DNA DNA DNA

’  
□(The Language of Life), □ (Francis Collins)가  
□(Language of God)  
DNA 가 DNA가

DNA  
DNA  
가 DNA •RNA( )  
‘ , DNA ‘  
DNA가 , .

가? □ DNA가 □ DNA가 가  
가? 가  
DNA가 , 가  
가 , 가  
DNA  
DNA , .

2. (systems) .

DNA 가 . 가 (complex systems)  
. 가  
가 . 가  
가 . 가

— , , — .

가 (器官) . 가  
, ,  
.

RNA

DNA가

(Crick, 1970) ,  
DNA

가

가

가

DNA

'

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가

DNA가

가

. DNA

가

DNA

•RNA•DNA가  
가

DNA

, RNA

가,

가

가

가

가

DNA

DNA

DNA

DNA

' , ' , ' , ' . ' '(expression)

DNA

DNA

DNA가

가

DNA가

“ (transcriptional variation) ” (Chick et al., 2016)

24 (the circadian rhythm) DNA가 가 (Nakajima et al., 2005).

DNA 가 DNA (Nobel, 2003)

DNA DNA DNA DNA

DNA “

가 가 (emergent properties)

‘DNA’ (a relational model)

RNA (input) DNA RNA

(Carl Woese)가 ‘

가

(Denis Noble)

가 가 DNA

3. DNA가 ' ' 가 ' ' ?

DNA가

RNA

(viroid)

DNA

DNA

RNA

RNA가

RNA가

DNA

DNA RNA

RNA DNA

RNA DNA

□ RNA

( ) DNA

□ RNA

DNA

(modification)

가

. ( A, C, G, T 가 ) DNA

가 가 DNA

가 (epigenetics)

. RNA 가 (A, C, G, U) 가

RNA가

□ RNA DNA

1%

가

99%

RNA

DNA

□ RNA가 DNA

. RNA

가

가 RNA

RNA가

DNA

RNA가

DNA

RNA

가 DNA

. DNA

(司書)

가

DNA

가

RNA

가

DNA

가

RNA

#### 4. DNA

DNA

『 』

DNA가

가

가

1.

2.

DNA

가

( , , ) DNA가 가  
(Carter, 2016).

( )  
『 』

가 가 (e.g.  
Kauffman, 1993; Carter, 2016). DNA가  
가

DNA가 가 가  
가 (Batten)

“ (“Self-organization proposes what natural selection disposes”)  
(Batten et al., 2008)

. DNA

3

(Munson et al., 1996). (+

charge ) . DNA가

DNA

(PH), □

3 (APT) , (chaperones)

(molecular channels) 가 가

DNA

DNA ( )



(ultra-determinist)

가

DNA

DNA

가

가

(Patrick Bateson)—

— “  
(genotypes)

”

가

DNA가

DNA가

DNA가

가

가

5.

가

RNA

DNA

가

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DNA

DNA

(種)

DNA

DNA

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가

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DNA가

(落果)

## 6. DNA

(Robert Rosen) “

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DNA  
RNA

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DNA

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DNA

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DNA

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(e.g. Kaufman, 1993; [Strohman, 1997](#); Rose, 1999;

Woese 2004; Annala and Baverstock 2014; Friston et al., 2015).

가

DNA

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가

(Ioannidis, 2007; [Dermitzakis and Clark, 2009](#); [Manolio et al., 2009](#)).

가

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(Pasteur)

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(Carl Woese)

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([Badylak, 2016](#)).

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.([Strohman, 1997](#))

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7.

(Helmholtz machine)

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(reviewed in Clark, 2013).

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가

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“ ”

“ ”

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가

가

(Friston, 2010).

(the vascular system).

2  
2008).

(Wheeler and Stroock,

( 掌心).

가

(metabolon) .

(metabolon)

3  
(metabolic pathway)

30%  
(Laursen et al., 2017).

(homeostasis)

가 . 24 .

가

가 . 1972

(Nicolas Rashevsky)

(Robert Rosen) AH (AH Louie)가 .

가? (What is life?)

(Erwin Schrödinger), (Stuart Kauffman), (The Origins of Order,

1933) (Stuart Kauffman), :

(Lifelines: Biology beyond determinism, 1997)

(Steven Rose), (The Art of Genes, 1999)

(Enrico Coen), (The Music of Life, 2003)

: (Dance to the Tune of Life: Biological Relativity,

2017) (Denis Noble), 2

(Annala) (Baverstock) .(Annala

and Baverstock, 2014; see also Friston et al., 2015).

가

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가 'RNA

'RNA ' DNA '

가 'RNA '

' -RNA ' 가

-RNA (Carter, 2016) RNA

가 ( ) 가

(1 2 ) 가

. 1 2 ( 가

) 가

RNA

가 (Carter 2016). RNA

RNA 가 가 가

가

. RNA

-RNA

가

, RNA가

(a replication-first theory)

(a metabolism-first theory)

RNA

8. DNA ( )

“

가

(life)

가

가

가

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가

.” [Anand et al., 2008](#))

(Craig Venter)

가

가

DNA

‘ , ‘ ,

DNA

가?

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가?

가?

Meaning of Life”) , 「 □(“The



## References

Anand et al (2008) Cancer is a Preventable Disease that Requires Major Lifestyle Changes. *Pharm Research* 25: 2097-2116.

Annala, A and Baverstock K (2014) Genes without prominence: a reappraisal of the foundations of biology. DOI: 10.1098/rsif.2013.1017

Badylak, S (2016) Work with, not against, biology. *Nature* 540: S55 doi:10.1038/540S55a

Batten, D, S Salthe, F Boschetti (2008) Visions of evolution: self-organization proposes what natural selection disposes. *Biological Theory* 3: 17-29.

Carter, C (2016) An Alternative to the RNA World. *Natural History* Dec 2016/Jan 2017 28-33.

Chick JM, Munger SC, Simecek P, et al. (2016) Defining the consequences of genetic variation on a proteome-wide scale. *Nature* 534: 500-505.

Clark A, (2013) Whatever next? Predictive brains, situated agents, and the future of cognitive science. *Behavioural and Brain Sciences*



Coen, E (1999) *The Art of Genes*. Oxford University Press.

Crick, F (1970) Central Dogma of Molecular Biology. *Nature* 227: 56-63.

Dermitzakis E.T. and Clark A.G. (2009) Life after GWA studies. *Science* 326: 239-240.

Friston K. (2010) The free-energy principle: a unified brain theory? *Nature Reviews Neuroscience* 11, 127-138 doi:10.1038/nrn2787

Friston K, M Levin, B Sengupta, G Pezzulo (2015) Knowing one's place: a free-energy approach to pattern regulation.

Ioannidis J.P., Non-replication and inconsistency in the genome-wide association setting. *Hum Hered*, 2007. 64(4): p. 203-13.

Kaufman S (1993) *The Origins of Order*. Oxford University Press.

Laursen et al., (2017) Characterization of a dynamic metabolon producing the defense compound dhurrin in sorghum. *Science* 354: 890-895.

Manolio T. et al. (2009) Finding the missing heritability of complex diseases. *Nature* 461: 747-753.

Mullis K *Dancing Naked in the Mind Field*. 1998, Vintage Books.

M Munson, S Balasubramanian, KG Fleming et al. (1996) What makes a protein a protein? Hydrophobic core designs that specify stability and structural properties. *Protein Science* 5: 1584-1593.

Nakajima M. et al., (2005) Reconstitution of Circadian Oscillation of Cyanobacterial KaiC Phosphorylation in Vitro. *Science* 308: 414-15.

Noble D (2003) *The music of life. Biology Beyond Genes*. Oxford University Press.

Noble D (2017) *Dance to the Tune of Life: Biological Relativity*. Cambridge University Press.

Rose S (1997) *Lifelines: Biology beyond Determinism*. Oxford University Press.

Strohman RC (1997) The coming Kuhnian Revolution in biology. *Nature Biotechnology* 15: 194-200.

Tudge, Colin (2013) *Why Genes are not Selfish and People are Nice*. Floris books.

Watson JD (2003) *DNA: The Secret of Life*. Alfred A. Knopf.

Wheeler TD and A Stroock (2008) The transpiration of water at negative pressures in a synthetic tree. *Nature* 455, 208-212 doi:10.1038/nature07226

Woese CR (2004) A new biology for a new century. *Microbiology and Molecular Biology Reviews*, 68: 173-186.