SISSA – International School for Advanced Studies Journal of Science Communication
ISSN 1824 – 2049 http://jcom.sissa.it/

Article

Metaphors of DNA: a review of the popularisation processes

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This article offers a 1953-present day review of the models that have popularised DNA, one of the fundamental molecules of biochemistry. DNA has become an iconic concept over the 20th century, overcoming the boundaries of science and spreading into literature, painting, sculpture or religion. This work analyses the reasons why DNA has penetrated society so effectively and examines some of the main metaphors used by the scientists and scientific popularisers. Furthermore, this article, taken from the author's PhD thesis, describes some recent popularisation models for this molecule.

Introduction

When, back in 1869, Friedrich Miescher isolated for the first time the DNA molecule (deoxyribonucleic acid), it was impossible to imagine that there in his hands he had the molecule that would have become the symbol of an age. Miescher, a Swiss biochemist, had just isolated a substance that he called *nuclein*, as it was found inside the cell nucleus. However, at that time nothing was suggesting that the characteristics and the structure of that molecule, unveiled completely nearly a century later (1953), would have opened so many extraordinary paths to science and to the future of humankind. Since that crucial year 1953, scientists and scientific popularisers have had to face the difficult task of popularising the DNA structure, composition, characteristics and functions among the general public.

The role played by a journalist or a scientific populariser is essential in correctly spreading information within contemporary societies. Science communication is the process through which the non-expert general public receives information on the knowledge produced by the specialists in a scientific discipline.[1] The two fundamental channels for science communication are education and the mass media, yet others do exist, and they range from conferences to science theatres, passing through museums an exhibitions.

As previously mentioned, DNA as a popularisation subject has gone through two phases, one pre- and one post-1953. Before that year, the interest in spreading knowledge about this molecule was relatively low. Starting from then, efforts to that purpose have doubled. In 1944 DNA was identified as a molecule carrier of the genetic heritage. At the end of the century, the chemical composition of the substance isolated by Miescher was already well known, yet its structure was still to be understood, a real puzzle. Erwin Chargaff in 1950 had achieved some mysterious results: by analysing the DNA of different individuals, he found out that the number of the nitrogenous bases varied from an organism to the other, but the quantity of Thymine (T) was, quite surprisingly, equal to Adenine (A) , and to Cytosine (C) and Guanine (G).[2]

Supported by data provided by the X-rays by Rosalind Franklin and Maurice Wilkings, the solution came in 1953 thanks to James Watson and Francis Crick. The journal *Nature* of 25th April 1953 reported the breakthrough news. From that very moment onwards, the knowledge about this molecule started to spread so quickly that, half a century later, DNA plays now a central role in the collective imagery.

Objectives and methodology

This article aims at analysing the DNA-related popularisation processes that have developed from 1953 up to today. A special focus is on the most well-known DNA metaphors, which have been one the most used methods to achieve the popularisation of this molecule.

Many of these metaphors have introduced to non-experts the structure and functions of that molecule. This article explores and discusses also some reasons behind the success some popularisation processes have had in spreading a complex concept such as the DNA molecule.

This work presents some recent original forms to approach DNA popularisation, such as the metaphor of the rung ladder, devised by Spanish journalist Javier Sampedro, which is particularly suitable for educational contexts and the media.

In short, the contributions contained in this article can be considered from three viewpoints: (a) to examine the DNA popularisation process and to present some reasons for its success; (b) to gather and comment on the most significant metaphors that helped popularisation, and (c) to put forward some proposals for new metaphors and popularisation processes to be introduced into academic and professional circles.

The metaphors were gathered through the following procedure: the fundamental literature on DNA popularisation has been systematically revised, predominantly the one from the Anglo-Saxon world. This sector includes the production of texts by some of the most influent scientists and popularisers of the 20th century, including F. Crick, J. Watson, R. Dawkins, G. Gamow, C. Sagan, S. J. Gould.

On the other hand, the collecting process involved also the metaphors used in the work by *El País* journalist Javier Sampedro, a reference science journalist in Spain. Substantially, the analysis involved a corpus of 532 texts published in *El País* by Sampedro between 1998 and 2003. Finally, the in-depth interview analysis was used with this author to understand the DNA-related popularisation processes in new metaphors such as the one of the rung ladder, devised by the author himself.[3]

The data taken from those two main sources were processed as follows: an analysis was carried out to select the metaphors that achieved a widespread knowledge, to exclude the ones whose public popularisation has not been so successful. Other metaphors were selected *ad hoc*, given their relevance to some aspects of the investigation. This research was carried out in compliance with the content analysis methodology developed by Krippendorff.[4]

The theoretical context: the popularisation process and the metaphor

The high specialisation levels have produced a knowledge gap between scientific knowledge and popular culture. To tackle this issue, it was necessary to create new channels and specific forms for science popularisation, which has led to a “double narration” of the scientific adventure.[5]

Bucchi maintains[6] that the problem lies in the fact that the transfer of communication is continuous between scientists and the public, yet on different and parallel levels, up to reaching a point where there is neither interaction nor contact between the professional scientific discourse and the scientific discourse of the common people.

Many authors such as Ciapuscio,[7] Cassany, López and Martí[8] have clearly stated that popularisation is a task that implies recreating the scientific knowledge for each type of public. A good science populariser should therefore write a new text, reformulating the concepts in a discursive way.

A populariser should turn scientific works - that feature a technical and complex language - into texts comprehensible to a general public. An author should neither adapt nor sum up a technical text, but they should completely revise it, starting from the ideas drawn from the introduction, through selection, enlargement, reorganisation and reformulation. The recreation process may also be seen as an engineering task whose goal is to establish connections between the technical aspects and the readers’ interests.[9]

A science populariser is not only required to be a good explainer, but also to make “a creative effort”, which is to favour a popularisation spirit.[10] Creativity is boosted by the instruments of literature, in order to present science as a dynamic knowledge, full of life, in which concrete things do happen and have to be explained because society is concerned. A populariser should communicate to the public what the French research Pierre Fayard (1991) has called “the science’s dimension of human adventure”,[11] i.e. the human side of science.

To relate to the general public, writers, journalists or scientists avail themselves of a “set of tricks having different effects”, which include synonymy, exemplification, definition, metaphor, analogy, anecdote, authoritative quotations or, among others, the explanatory apposition.[12] It would be interesting to dwell upon the metaphor, probably the leading instrument of this set, that is able to provide wit to the writer’s creativity and to attract the reader in an evocative way.

The study of the metaphors has developed in the past three decades starting from the work of scholars including Lakoff, Johnson, and Goatly. Starting from cognitive linguistics, Lakoff and Johnson[13] opened the theoretical field of the "conceptual metaphor" introducing the thesis that the metaphor, aside from being a formal aspect of language, allows human beings to structure some concepts on the basis of others. Starting from functional linguistics, Goatly[14] has developed different systems to understand how a metaphor works in real communication and, in particular, how it is processed by the public.

There are different theoretical approximations for the metaphor concept in science popularisation. Liakopoulos[15] has identified some potential advantages of the metaphor and has highlighted three social functions: it provides a touch of imagination, which results in a feeling of pleasure in the receiver; it creates a certain feeling of intimacy between the communication parties (emitter-receiver), and builds up knowledge, since it creates/changes the relations between the novel concepts and those already known.

Besides, it is worthwhile to mention the studies on science popularisation from an educational point of view. Wellington and Osborne[16] have highlighted the importance of language in scientific education, stating that science classes are first of all language classes. These authors have stressed that language and its properties have had little recognition in science education centres.

Other approaches have identified the metaphor as an instrument of scientists for their discoveries. Brown says[17] that the metaphor is an investigation and discovery tool for scientists. The scientific reasoning is what scientists do when planning experiments, achieving a breakthrough, formulating theories and templates and when presenting their results to others; in short, when they carry out science and communicate it. Somehow, scientists understand the world in terms of metaphoric concepts.

There are different classifications for metaphors in scientific popularisation, such as the one devised by Christidou, Dimopoulos and Koulaidis[18] in a study on science popularisation in the Greek press. The authors maintain that all the metaphors of science and technology can be grouped in four large categories: (1) science and technology as a construct, such as a handiwork, a work of art, etc. (2) science and technology as a supernatural process, (3) science and technology as an activity that enlarges the knowledge frontiers and (4) science and technology as a duality of promise and/or scare. According to their empirical studies, the most frequent in these categories is the third one, i.e. presenting science as a path to explore uncharted territories, a "structuring activity" that "provides a feeling of order".

Basically, the metaphor – like the analogy, the image and the simile, which in this context have the same value – is an instrument with a "high motivational power"[19] and possesses an "extraordinary strength", as it helps to explain unknown facts by relating them to what is already known. The best metaphors and similes probably are those that refer to aspects of daily life and that act as a bridge between the abstract world of science and the tangible world of everyday life.[20]

Results

There are at least four factors that have favoured the processes introducing the DNA molecule in the collective imagery: (1) the initial popularisation (pre-1953 articles) had already been very good; (2) the double helix structure had been adopted as a theme in the works by several artists, which helped its spreading; (3) the genetic information it contains has given it the life-bearer molecule status, to the detriment of the water molecule, and (4) a wide range of evocative metaphors have contributed to its effective popularisation.

The DNA molecule popularisation process had an excellent starting point. The article by Watson and Crick (1953a[21]), published on *Nature*, extraordinarily brief and clear, was at the same time the presentation of a historic breakthrough and – considering the high editorial quality of the text – an outstanding example of popularisation. The communication starts with two memorable sentences: "We wish to suggest a structure for the salt of deoxyribose nucleic acid (D.N.A.). This structure has novel features which are of considerable biological interest."

Far from the obscure rhetoric of many scientists, the text presents two sentences that represent the "sensational hit". In the first part of the article, Watson and Crick clearly stress the novelty of the structure: "We wish to put forward a radically different structure" that "has two helical chains each coiled round the same axis". Towards the end, a second "sensational hit": "It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material". This statement was opening a range of possibilities for Biochemistry that are not exhausted as yet.

It was a text that could be read quite easily also by non-experts – an exception to the complex method used by many scientists in the 20th century. The text complied with one of the principles set by its co-author Francis Crick as regards scientific writing: “Write your article in a clear and tidy fashion, so that everybody can understand it”.

The article saw the first-ever appearance of the English acronym DNA (*Deoxyribose Nucleic Acid*), although Watson and Crick wrote it with dots (D.N.A.). Until then the journal *Nature* had never used this acronym, which was to spread quickly within scientific and non-scientific circles.[22]

The second previously-mentioned factor concerns art. The DNA popularisation has highly benefited from the aesthetic potential of its structure. Beauty can be attached to the subtle combination of round shapes of the double helix and the feeling of infinite suggested by the two long chains of deoxyribose and phosphoric acid united to form the salt structure.

Non-experts of biochemistry could then associate a complex molecule to a visually-pleasant and easy-to-remember structure. Moreover, the most avant-garde artists of the 20th century welcomed enthusiastically the structure described by Watson and Crick. One of the greatest admirers of the molecule was painter Salvador Dalí.[23]

The Catalan artist, who showed a constant interest in scientific discoveries in all disciplines, included the DNA structure in many of his paintings, such as *Galacidalacidesoxyribonucleicacid*, *La escalera de Jacob* (Jacob’s ladder), *La estructura del ADN*, (DNA structure), *Árabes aciddesoxiribonucleics*, *Paisaje de mariposa. El gran masturbador en paisaje surrealista con ADN* (Butterfly landscape. The great masturbator in a surrealist landscape with DNA).[24] Likewise, many other painters, sculptors, architects exploited the elegance of shapes and proportions of the molecule as an theme for expression. For example, the artist Roger Berry built a large sculpture (*Retrato del ADN* – DNA portrait) at the headquarters of the University of California and the architect Charles Jenks created another sculpture (*Spirals Time*) that stands in the garden of the Cold Spring Harbour Laboratory in New York.

Thus, art put itself at the service of popularisation, in an emotional merging of science and art, two worlds which were growing separate owing to the increasing knowledge-specialisation trend. Probably nobody has defined this iconic character of the DNA structure better than Kemp (2003) who, using a fascinating artistic metaphor, said the double helix was the “Mona Lisa of modern science”.[25]

The third reason for which DNA has become so popular is the fact that this molecule was constantly associated to the concept of life. DNA has achieved the maximum degree a scientific concept can achieve, i.e. being identified with existence itself; these organic chains have become “a sacred molecule”, a “philosopher’s stone”, a sort of beginning to everything,[26] leading them to acquire a “mythical” meaning in popular culture.[27]

The “divinity” character of the molecule became patent at the time of the presentation of the Human Genoma Project (HGP) in 2000. The former President of the United States Bill Clinton associated this idea with the popular linguistic metaphor (DNA = language) to refer to the human DNA sequence: “today, we are learning the language in which God created life”.

The concept of life is often reinforced by the notion of immortality. DNA is an “immortal spiral”, said Richard Dawkins.[28] This metaphor achieves two results: on the one hand, the noun “spiral” recalls the 3-D helix shape of the two DNA chains and, on the other hand, the adjective “immortal” refers to the invariability of the molecule passed down generations of individuals.[29] On other occasions, DNA has been seen as the “supreme” molecule, the “eternal” molecule, and that has given it an ontological value which is totally unusual for a chemical substance. This characteristic of the “life molecule” has relaunched the interest in its understanding which, on its turn, it has given momentum to its popularisation.

The fourth factor regards the set of metaphors that have consolidated the status of DNA as a popular object. The most popular metaphor is the one of information (DNA = information). It is an old association of ideas that dates back to the origins of genetics, when research was carried out into the molecule (initially thought to be proteins) that should have contained the information to duplicate cells and organisms. In this type of popularisation model, DNA was identified with many everyday-use objects able to store information: a computer file of living beings, a database for each species or a library with all the information about an individual. To Dawkins, the human DNA is a “user guide to build a living being” or “the architect’s designs to build a building”.

Nelkin and Lindee[30] have deservedly criticised some of the last statements above. Nelkin criticises especially the metaphor of the “blueprint” (a detailed plan used in engineering and architecture), since it assumes that DNA determines it all, as if already planned beforehand. This type of metaphors “are confusing rather than enlightening” and turn into a persuasion instrument at the service of scientist’s interests. They start from a false assumption: “when a gene is found, its interpretation will be objective and independent from the context”. And the context is as important as or even more than what genes dictate.[31]

Regarding genetic determinism and the discriminatory attitudes of the public, Celeste M. Condit has warned that if this cause-effect relation is assumed to be absolute and certain, somebody may be discriminated because they have a specific genetic profile. For example, when having to find a job. This can lead to an underclass of individuals discriminated because of their “poor” genetic features.[32]

However, DNA is a special molecule: it does not contain casual information, but a vital (it allows reproduction) and coded one (the nitrogenous bases make up a code to be decoded). DNA hides the “secret of life”, as Crick and Watson announced on 28th February 1953 to the customers of the “The Eagle” pub, in Cambridge, when they celebrated the discovery of the structure. The nouns *secret*, *code* and the verbs *to decode*, *to decipher*, have always been connected to the molecule, this way made a symbol to go into what remains obscure, incomprehensible and hidden. In fact, the mystery surrounding DNA has also been the visible driving force to its popular status within society.

Likewise, even the volume of information stored in human cells has lead to metaphors. The size of the DNA sequence coiled up within each human cell has been explained through transposition and parallelism. The popularisation mission has allowed to discover an image to summarise its unimaginable volume, an idea Watson expressed in 2000: “None of those who had the privilege of seeing for the first time the double helix of DNA has ever though of living long enough to see it completely decoded”.

Two of these metaphors on the volume of information have entered the practice through books. Usually this order was given through sentences such as: the DNA sequence of a human being could fill a “61-metre-high pile of books” or would fill “200 to 500 telephone directories”.

A more brilliant and effective transposition is the one between the macroscopic and microscopic world. If the DNA segments could be stretched without breaking them up, a single person’s DNA would be enough to “reach the sun and back”. The history of science is rich in such a type of associations. Early in the 20th century, the Danish physicist Niels Bohr had already used the planetary system to explain microscopic phenomena when he introduced his atom model, made up by a central nucleus (the Sun) and a group of electrons (the planets) revolving around it.

The information-related metaphor has developed a range of unquestionably effective images connected with texts and letters.[33] This model (DNA = language or text) is based on the sequence of the nitrogenous bases in the chains of the molecule, the real secret of life, represented by only four letters: A (Adenine), C (Cytosine), G (Guanine) and T (Thymine).

This new alphabet, besides limited, is also a bizarre one, as *A* only combines with *T*, and *C* only with *G*. According to the most common metaphor, this four-letter alphabet (nitrogenous bases) makes up a text (DNA) which is different for each living being. This implies further metaphors: DNA is some kind of “fingerprints” or of “ID”,[34] unique for each individual.

Usually the text metaphor leads to the conclusion that texts can be “copied”, as the order of the letter allows for perfect replicas. Thus, it is possible to explain the secret of life, i.e. cells can be replicated and human beings can therefore reproduce.

The DNA model as a text with determined letter has been widely used by teachers, journalists and scientific popularisers, yet it does not work properly. One of the major problems is it does not provide for a 3-D view of the nitrogenous bases in the molecule and so the location of the letters in the text (the bases) in the structure of the double helix can be hardly imagined by the reader.

Another very common popularisation strategy is the template metaphor (DNA = template). This model is appropriate to explain the DNA replication process and had been already introduced by Watson and Crick in a scientific article published later in April 1953. The metaphor associates an object of daily life, a template, with each of the helixes of the organic molecule. Watson and Crick (1953b) wrote it as if they were scientific communicators: “Now our model for deoxyribonucleic acid is, in effect, a *pair* of templates, each of which is complementary to the other. [...] Each chain then acts as a template for the formation on to itself of a new companion chain, so that eventually we shall have *two* pairs of chains, where we only had one before.”[35]

The idea of a template implicitly contains the concept of replica and, somehow, also the complementarity of space, a crucial aspect in the replicating mechanism. This model has been handed down to these days, over half a century later, and is still valid and widely used in the academic and journalistic world.

A recent popularisation technique, and possibly a more advanced one, is the metaphor of the rung ladder, which combines perfectly with the one of the text and of the template. The starting point of this model (DNA = rung ladder), put forward by Spanish journalist Javier Sampedro,[36] is the double helix structure. Subsequently, the two imbricated springs, or trigger elements (the double helix), are stretched from the extremes until they lose completely their wavy shape.

Then, the populariser wants us to imagine a rung ladder in which the two springs, now completely stretched, are the vertical ladder rods. This popularisation model allows us to focus our attention on the ladder rungs, the key point at scientific level. Each ladder rung is now a couple of nitrogenous bases (A, C, G, T) united by hydrogen bridge links.

The only couples to be found on the ladder rungs are A combined with T and C combined with G. If on one side of the ladder you have the sequence …AGTGC…, on the other side there will necessarily be …TCACG…

This model can be best exploited if the central crossbars are sawed. At this point the replicating process is evident, as each rod obtained can regenerate the opposite rod, following the rule of the A-T and C-G complementarity. The result of this whole process is that where once there was a rung ladder, now there will be two identical ones.

This way, the complex step of replication can be understood very intuitively. The use of this metaphor is thus particularly useful when addressing publics not very familiar with science. The rung ladder metaphor tackles in its turn the problem of the spatial conception of the nitrogenous bases in the double helix.

Starting from the rung ladder metaphor, the popularisation process may be carried out through different variants as examples, something leading to a network or cluster of metaphors, all of them at the service of a single objective: to transfer a technical concept, DNA, to heterogeneous publics.

A similar variant of this model, especially as far as the replica is concerned, has been often implemented through the image of a rack that opens when a copy is required. The same result could be achieved imagining a railway track, with sleepers being a metaphor for the specificity of the unions of the nitrogenous bases and, subsequently, developing the copy process of each track in order to obtain two identical railway lines.

With DNA becoming more and more popular, it has gradually become the starting point for new images, similes and metaphors, and this is an excellent example of the fact that a very specialised word can be a substrate to figures of speech to explain other concepts, scientific and non-scientific ones.

In these new metaphors, DNA was used to associate it to concepts such as: twisting, embracing, uniting, creating, recreating, surrounding, testing. Three examples will be now considered: it has been said that the dynamics of an organisation require “the DNA metaphor”, i.e. “two chains should be united to create something new and unique”. In this first case, DNA is used to demonstrate that, for the proper functioning of an organisation, it is necessary to connect two branches of an organogram with a view to create a better working group.

The second example is similar to the first. When Crick passed away, somebody said that “the DNA structure was not double any more”. In this case the twisted structure of the molecule was seen as the link between the two scientists that discovered it.

Furthermore, the DNA concept has been applied to the legal field, stressing the infallibility of the molecule in solving some cases. Now this is the third example: “The backpack found unexploded on the 11th March in Madrid was the DNA to the attack”.[37] In this sentence, DNA has acquired the meaning of a Gordian knot to solve a case, as if the object found were a map leading to the criminals.

On a different level, some typical human qualities have been attached to DNA. One of the most popular personifications sees the DNA as “selfish”, because the purpose of the molecule always is its endurance, its replicas. DNA is selfish owing to its obsession for survival.

Similarly, by studying the sequence of the nitrogenous bases, it is possible to notice that the molecule is selfish as it contains many useful information and repeated segments, as if DNA never got rid of anything. It is just as if DNA had an obsession to pile up information that is apparently useless, as if it suffered from the syndrome of Diogenes and stored large quantities of garbage and objects in its structure.

Conclusion and discussion

Over the years DNA has ceased to be an acronym for experts only and has touched the heart of the people, largely thanks to a wide and effective range of popularisation strategies, where the metaphor is the protagonist. During the past half a century, DNA has been identified with information, with language, a text, a book, a file, a database, a plan, a template, an immortal spiral, a rack or a rung ladder.

One of these metaphors, the rung ladder, allows to establish a novel popularisation sequence, improving other previous formulations. This metaphor helps to understand better the role of the nitrogenous bases in a molecule and allows to explain satisfactorily the replication process. As illustrated in this paper, the rung ladder metaphor reduces the structural complexity of the double helix and forces non-experts to focus their attention only on the rungs, the key concept for the theoretical understanding of the structure and function of the DNA.

Scientists and popularisers should continue to devise novel popularising processes, on DNA as much as other complex scientific terms, to facilitate the hard popularising task and to make it from a critical perspective to avoid unwanted events, such as excessively propagandistic, unclear or deterministic approaches, that erase or diminish some human values.

A critical populariser should be careful with the risk of presenting genetics in a deterministic way, especially in those cases in which all the human behaviour and the features of the character (alcoholism, crime, aggressiveness, etc.) may seem driven by DNA, as if improving society would only imply improving a molecule in a laboratory. Science and technology need social and cultural values and need also to express suitably the human context in which they develop.

Also, a critical populariser should realise if the social extension of a metaphor is part of illegitimated strategies used by scientists, e.g. to obtain public funds or to influence the scientific policy of governments.[38] In the end, metaphors should not be anything but metaphors. Or, even better: metaphors used for constructive purposes.

The description of this structure shows that DNA is a molecule rich in scientific and social meanings. It owns the virtue of uniqueness, the ability to replicate, to copy itself, to reproduce, artists find it beautiful, it is associable to life, immortality, it makes all the living beings equal and, at the same time, it differentiates them. These features of DNA explain its deep penetration in the collective imagery and some of its iconic and symbolic connotations.

In the century of the communication and the society of knowledge, DNA has become the symbol for a time, an age, as a single molecule that has been able to represent an entire way of living and thinking. Worshipped by painters and sculptors, the double helix structure recalls the scientific method and symbolises the struggle of the human beings to approach a fascinating challenge: understanding the very concept of life and its secrets.

Certainly, the whole of the DNA popularisation processes have contributed to bring closer the discourse of scientists to the one of the general public. Or else, to follow Bucchi’s metaphor on science communication, it has helped to make both discourses imbricate in the double helix between science and public. An interwoven relation between both discourses is the path that Bucchi proposes to fill, at least partially, the knowledge gap existing in the technologically developed societies.

Thanks

I would like to thank all the anonymous referees for having me invited to clarify some essential points

Translated by Massimo Caregnato

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