Journal of Applied Sciences

ISSN 1812-5654

science alert

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 11 (7): 1249-1254, 2011
ISSN 1812-5654 / DOI: 10.3923/jas.2011.1249.1254

Does Phenotype-genotype Distinction Apply for Simple Molecules?: A Thought in the Chemical Philosophical Context

[1]Bambang Ariwahjoedi and [2]Setyamartana Parman
[1]Department of Fundamental and Applied Sciences,
[2]Department of Mechanical Engineering,
Universiti Teknologi PETRONAS, Bandar Seri Iskandar,
31750 Tronoh, Perak, Malaysia

Abstract: By taking the analogy with bio-molecular systems, many systems containing simple molecular entities like water could have an information storage system. This storage system is similar to a gene locus which is presumably enclosed within the nucleus of its atoms. Information are stored in the form of perhaps such kind of fundamental interactions among sub-sub-atomic particles within each nucleons, just like hydrogen bonding among the nucleotides residue in the DNA. If this is true, then small molecules, water molecules for example, might be no longer as all-identical entities, instead they might all be organisms, which each of them is individually unique in their own. Furthermore, if this could someday be comprehended, many natural phenomena which are still not well understood due to their complexity such as cloud morphology in the sky, crystallization pattern of snow flakes and crack pattern in drying clay mud, etc., could be rationalized in a fundamental way, still by using physicochemical if not nucleo-chemical principles.

Key words: Phenotype-genotype, simple molecules, small molecules, collective phenomena genes, codon, chemical philosophy

INTRODUCTION

This study was inspired by work by Psarros (2001) from the Philosophical Institute, University of Leipzig. Psarros cited from the famous lecture by Michael Faraday entitled: Chemical History of a Candle (Faraday, 1993). This lecture was presented by Faraday in front of the children in the Royal Institution of London on the Christmas Day of 1860.

Michael Faraday's lecture was aimed at providing an exact and correct explanation on the elemental composition of a candle and the reaction products that formed during the combustion of the candle (Eq. 1), which in this case is represented by hydrocarbons.

$$C_nH_{2n+2}(s)+\frac{(6n+2)}{4O_2(g)}\rightarrow nCO_2(g)+\frac{(2n+2)}{2H_2O} \quad (1)$$

In the lecture, one of Faraday's claims was that if candle is burnt it will give a liquid product which is known as water. Water resulting from the combustion reaction, was convinced by Faraday as a compound which is going to be the same as water which can be obtained from any sources, either from the combustion of oil, gas, or steam vapors, or even from the pond, river as well as the ocean, through distillation.

In this study, the authors will question philosophically the above mentioned Faraday's statement. Is it true that simple molecules like water are molecules which are exactly identical from one among the other? Or is it just because of our knowledge that is still not advanced enough, or we do not have sophisticated enough techniques or instruments that are able to discriminate between one water molecule and the others? In other words: Does Phenotypic-genotypic Distinction which normally applies for organisms the genetics/biology also apply for simpler chemical molecules such as water?

PHENOTYPE-GENOTYPE DISTINCTION IN BIOLOGY

Genotype is a characteristic genetic arrangement (characteristic genome) of an individual organism, in general in the form of Deoxyribo Nucleic Acid (DNA) which was inherited to the offspring organisms by the corresponding parental organisms at the conception event of the organisms. Genotype in fact codes the

Corresponding Author: Bambang Ariwahjoedi, Fundamental and Applied Sciences, Universiti Teknologi PETRONAS, Bandar Seri Iskandar, 31750 Tronoh, Perak, Malaysia

authentic phenotype of the individual organism. Genotype of an organisms is an exact genetic make-up, i.e., in the form of a collection of genes (Fig. 1) (basically an information) which are possessed by those organisms (Churchill, 1974; Beurton *et al*., 2000).

Two organisms which posses at least one gene locus (position in the genome) are said to have different genotype. The term genotype is therefore, refers to the whole inherited information from an organisms (Churchill, 1974).

On the other hand, phenotype of an organism, depict physical properties and obvious behavior such as body height, weight, hair and eye colors and others. The mapping from a collection of genotype towards a collection of phenotype is known as the term genotype-phenotype maps.

Genotype of an organism will give the higher influence factor in the formation of the phenotype of an organism, although it is not the only factor which determine the effect in an important way. Still there is an environmental effects. Even two organisms with very similar genotypes will result in different phenotypes due to the environmental influence. This is also part of our everyday experience in the case of mono-zygous twins (identical twins). Identical twins have the same genotype, since their genomes are identical, however both never been observed of having exactly the same phenotypes, although visually we can perceive that their phenotypes are very similar.

The fact that identical twins will always have phenotypic differences is that their mother or their close friends can always differentiate between them, although at glance, we can not really specify those slight differences. Furthermore, identical twins can be discriminated based on their fingerprints, which are not really possible to be identical.

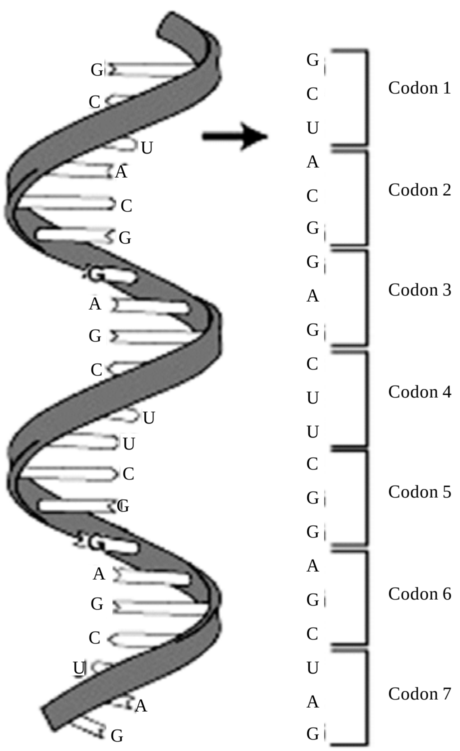

Fig. 1: Typical representation of gene by the genetic codon (D. Leja, National Human Genome Research Institute, http://www.genome.gov/12514471)

PHENOTYPE-GENOTYPE DISTINCTION IN THE BIO-MOLECULES AND THE ENVIRONMENTAL EFFECTS

Phenotype-genotype distinction has been known for so long to apply in the bio-molecular systems. A protein, which is a polymeric chain, which consists of monomers of amino acids, each of them, is coded by a triplet of nucleic acids from the DNA chains, which comprise of genes. Proteins will have either certain physiological activities or not, is highly dependent upon the identity of each of their amino acids residues. A slight change that happen on a certain critical parts of the genes which will results in the change of the corresponding important amino acids, could lead to the loss of the physiological activities of the produced proteins.

Nevertheless, it is nearly impossible to determine the corresponding change in the genotypes, only by observing the associated phenotypes, e.g., the loss in the physiological activities from a certain type of proteins. Only deep structural studies will find out about the phenotype-genotype relationship. In such a case it becomes a good and general example of multiple to single mapping of genotype to phenotype.

Complete sequence of DNA of an organism is known as not containing enough information to establish full physical characteristics of an organism. The output of the developmental process of organisms, which is observed as phenotypes is dependent upon genotype as well as toward the temporal sequence of the environment where the organism is grown. Schematically the phenotype-genotype distinction on macromolecules can be depicted in Fig. 2.

Genotype	→Phenotype	←Environment
Genome on DNA	→Protein Structure	←Physiological conditions

Fig. 2: Phenotype-genotype distinction in a biological macromolecules

PHENOTYPE-GENOTYPE DISTINCTION IN THE "SIMPLE" MOLECULES

If we consider all matters from the nucleons, atoms, molecules, viruses, cells and so on up to the stars in the universe as organisms then it will be quite apparent that as far as the science is concerned, in the organisms itself there is a typical organization which more or less hierarchical. The organizational structure is often centralized with the central part controls and determines the peripheral parts, this can be clearly seen from atomic nucleus, cell nucleus, nucleus of the solar system which is the sun, nucleus of the galaxy and so on.

As with their biological molecules counterpart, simple molecules can also breed (some kind like a reproduction). In an analogy with biological reproduction system which can be both sexual or non-sexual, then in the simple molecular case there can be a some sort of reproduction through normal chemical reactions from the reactant molecules which can be considered as parental molecules to produce reaction products which are the daughters or off-springs molecules, where via genetic inheritance principles, the information stored in more or less on the atomic orbital configurations or molecular orbitals of the "father" and "mother" molecules.

Simple molecules such as water can exhibit larger organization in the form of collective interaction (e.g., hydrogen bonding) in such a way to produce morphologies, which are quite organic. If the water molecules are all individually identical exactly to one another, then the extent of the interaction will always be same. And will not produce so many variations of the exotic morphologies of the cloud in the sky (Table 1) as well as infinite possibilities of dendritic/fractal morphologies of the snow flakes (Fig. 3) (Libbrecht, 2005; Salzmann *et al*., 2006). The huge or practically infinite kind of morphologies reflects more or less the organic varieties of their phenotypic appearances, which in turn originate from their genotypes.

Foreign matters as a nucleators (as environmental factors) suppose to function only on the initial stages of the nucleation processes. Furthermore, if there are compounds that modify the growth pattern, these molecules might act as the shape modifying factors. However, with or without the growth shape modifying compounds, intrinsic characteristics (genes) of the molecules, which might responsible for the vast amounts of the variations of the morphologies.

Discriminating descriptors among the molecules of the same type of compound (which in this case we will call as genotypes) have been known for so long in chemistry. Several knowledge from identical molecules which haves different characteristics which have been understood chemically so far, for example: resonance structures, electronic spins (high and low), nuclear spins (Rith and Schafer, 1999) (e.g., in the molecular hydrogen where there are ortho and para isomers), oxidation state of complex central atoms, distortion isomers etc.

Another analogy is that we cannot differentiate a large group of people when we see them from a distance. In a closer look, we can easily differentiate their phenotypes based on sexes, face, body height, hair color and curl, etc. A swarm of single species ants, is however much more difficult to discriminate from one another. By using magnifying microscope, the difference in the phenotype of each of individual ants can be differentiated such as number of the antennae in each of the mandible. If we change into the smaller object, for example the viruses or enzyme molecules, the difference in phenotypes can only be recognized through more detailed studies on their genotypes, i.e., the sequence of the genetic codes on their DNA genomes.

Furthermore, what if we reduce our object size into a collection of 6.023×10^{23} molecules of water (H_2O). In the elementary chemistry, we know this molecular object of water are all identical. One with another is just considered as clones which are the same and identical. But, is this understanding really true? Is there any conclusive proof that water molecules are totally identical with one another?

Measurements on bond lengths as well as angles have been carried out using microwave spectroscopy and crystal diffraction, toward molecular object in the form of group of large numbers of molecules. Thus the values which can be obtained are averaged of values, instead of value for a particular single molecule. This is similar to determining the body average height or weight of a human population and not weight or height of each individual values which are varied. The hope of the ability to characterize single molecule will rely on advanced techniques such as Scanning Tunneling Microscopy (STM) or Atomic Force Microscopy (AFM) in order to perform the dimensional measurement toward single molecules, if the precision of such measurements can be improved within the sub bond length order of magnitude.

Table 1: Classification of the clouds based on their morphologies (Wikipedia)

Family A (high clouds)	Family B (middle clouds)	Family C (low clouds)	Family D (vertical clouds)
Cirrus	Altostratus	Stratus	Cumulonimbus
Cirrus uncinus	Altostratus undulatus	Nimbostratus	Cumulonimbus incus
Cirrus Kelvin-Helmholtz	Altocumulus	Cumulus humilis	Cumulonimbus calvus
Cirrostratus	Altocumulus undulatus	Cumulus mediocris	Cumulonimbus mammatus
Cirrocumulus	Altocumulus mackerel sky	Stratocumulus	Cumulus congestus
Pileus	Altocumulus castellanus		Pyrocumulus
Contrail	Altocumulus lenticularis		

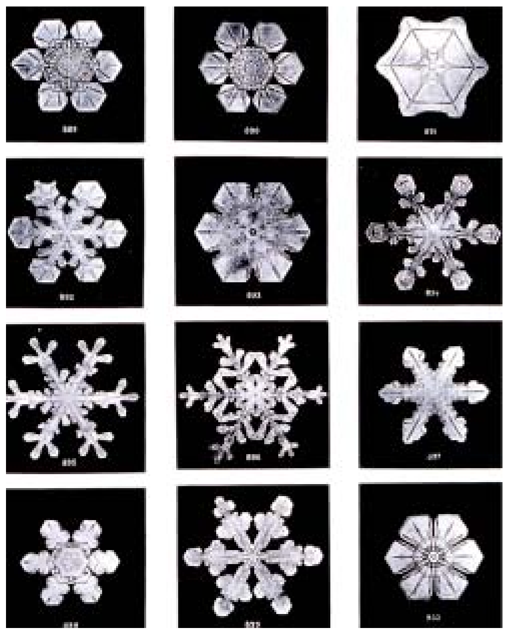

Fig. 3: Morphological examples of snow flakes from Wilson Bentley of 1902 (Drawn Association, 2010)

On the DNA genes are stored as the information of the codon sequences, which are preserved by the hydrogen bonding. These authors speculate that it is quite possible that the genes related to the simple molecules are stored as the different characteristics of the sub-particles of the nucleons inside the atomic nucleus, which bonded to one another with the fundamental interactions known as the strong and weak interaction forces (Quigg, 2008).

As an illustration that atomic nucleus can have detailed structural information, is supported by the fact that in the atomic nuclei there are quantized energy levels too (Fig. 4). If there is a quantized energy levels for the atomic nuclei means that in molecular system population, the atomic nuclei in each of the molecules will also have a certain population distribution, which basically each determined by their differences in terms of the nuclear structure. This has not counted the latest progress in the field of particle and high energy physics concerning the detailed structure of proton and neutron which so far we treat both as two structure-less solid sub-atomic particles in chemistry. Various possible nuclear combination of structure, which might lead to some sort of nuclear genomes, are shown in Fig. 5.

For example if we take water molecule where we have 8 protons and 8 neutrons for the oxygen atom and single proton for the 2 hydrogen atoms, we will have a huge possibilities of the combination of the nuclear genotypic codons. If the combination of 'colours' and flavours' as shown in Fig. 5 are used to specify each of the subatomic particles within each of water molecules, we will end up with a very large combination of the codons, comparable in amount to those of the base pair G-C and A-T in describing the genotypes of the micro as well as macro-organisms.

Genotypic understanding in simple molecular systems might imply the new understanding on complexity of cloud morphology in the sky. It might

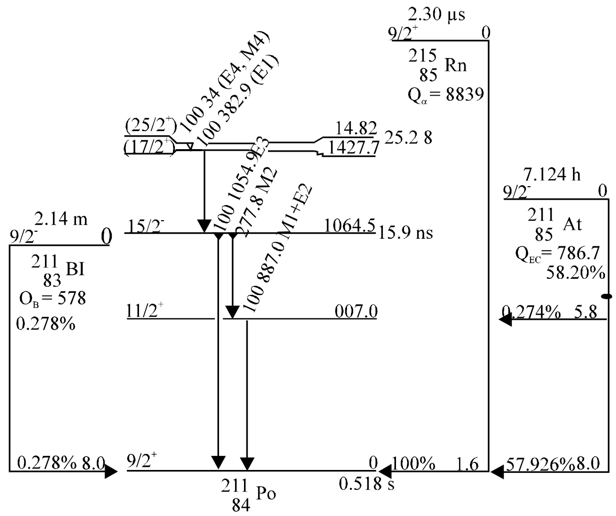

Fig. 4: Energy level diagrams of the nuclides ^{211}Bi, ^{211}Po ,^{215}Rn and ^{211}At which were determined from nuclear reaction experiment (Firestone and Shirley, 1999)

(a)

	Up	Charm	Top	
Up				Down
Charm				Strange
Top				Bottom
	Red	Green	Blue	

(b)

	Down	Strange	Bottom	
Down				Up
Strange				Charm
Bottom				Top
	Red	Green	Blue	

Fig. 5: Combination of elementary particles of possible nuclear genomes for (a) proton and (b) neutron

further explain intricacies in the snow flakes forms. It could even account for water molecular clusters such as ones claims in the so-called hexagonal water (Ariwahjoedi, 2004).

Among other examples are like how odors and smells could propagate from the scented objects, taste sense mechanisms on the tounge surface. Eventually, the claim of the effect of sound/acoustic wave toward the ice/snow crystals (Dewey, 2010) and the like are possible for an explanation.

CONCLUSIONS

From various points of discussions elaborated earlier, it appears that It is reasonable enough if we as chemists, respect simple molecules like water, no longer as dime-a-dozen dead objects without a unique personality, but as organisms too like other common products of super-creation.

Molecular studies, especially concerning isolated single molecule, are still in its infancy. It is still requires intergeneration hard works. In this case perhaps we require development into more accurate, precise and practical microscopes such as the STM as well as AFM which have been demonstrated to be able to display visually single molecule(s) adsorbed on the surface of solid crystalline substrates.

Furthermore, if the propositions in this study were true, then it is quite likely that water which we get from hydrocarbon combustion inside internal combustion engines, will differ than water obtained from catalytic reactions inside fuel cells for example. Only that our knowledge and techniques are not sophisticated enough to be able to discriminate those genotypic differences. Ones might insist by saying that water is always water, wherever it is and where it comes from, water is always H_2O.

From the advancement of chemical understanding as far as we can achieve until today, maybe that is the case, but if we extend the ideas that it might be possible for the sub-sub-atomic particles which construct the nucleons on the simple molecules are arranged in such a way that it resembles and functions like genes of the simple molecules or even atomic genes, which become genotypic information which subsequently act as the storage media of the temporal effects of the environment toward the whole molecular assembly, so perhaps the effort towards the research on such an atomic nuclear genomic information might have just begun.

On the other hand, if we accept the other way round belief that H_2O molecules are just exactly the same and identical from one another, then the research effort will not flourish. Our paradigm will just be confined within some sort of Molecular communism concept in chemistry which is static and dry.

ACKNOWLEDGMENTS

The author would like to thank for the class presentations and fruitful discussions to his former master students at the Department of Chemistry, Bandung Institute of Technology, Bandung, Indonesia whom in the period of 2004-2006 took the Chemical Philosophy KI7111 course.

REFERENCES

Ariwahjoedi, B., 2004. How to prove hexagonally structured water?. Proceedings of fgW Indonesian Food Conference, Oct. 6-7, Jakarta, pp: 234-250.

Beurton, P.J., R. Falk and H.J. Rheinberger, 2000. The Concept of the Gene in Development and Evolution. Cambridge University Press, Cambridge, ISBN-10: 0521771870.

Churchill, E.F.B., 1974. William Johannsen and the genotype concept. J. Hist. Biol., 7: 5-30.

Dewey, R.M., 2010. More messages in water. The Spirit of Maat Interviews Dr. Masaru Emoto. http://www.spiritofmaat.com/archive/nov1/cwater.htm.

Drawn Association, 2010. Capturing the snowflake: Wilson Alwyn Bentley 1865-1931. http://drawnassociation.net/2009/09/snowflakes-wilson-alwyn-bentley-1865-1931/.

Faraday, M., 1993. The Chemical History of a Candle. Cherokee Publishing Company, Atlanta, GA..

Firestone, R.B. and V.S. Sirley, 1999. Table of Isotopes. 8th Edn., Vol. II: A=151-272, John Wiley, New York.

Libbrecht, K.G., 2005. The physics of snow crystals. Rep. Prog. Phys., 68: 855-895.

Psarros, N., 2001. The Concept of Molecule in Chemistry Physics and Biology. In: The Autonomy of Chemistry in Relationship to Other Natural Sciences, Janich, P. and N. Psarros (Eds.). Konigshausen and Neumann, Wurzburg.

Quigg, C., 2008. The coming revolutions in particle physics. Sci. Am., 298: 38-45.

Rith, K. and A. Schafer, 1999. The mystery of Nucleon Spin. Sci. Am., 281: 42-47.

Salzmann, C.G., P.G. Radaelli, A. Hallbrucker, E. Meyer and J.L. Finney, 2006. The preparation and structures of hydrogen zordered phases of ice. Science, 311: 1758-1761.