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Nephrology: a prototype of a discipline evolving into complexity
The border with philosophy

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Νεφρολογία: Πρότυπο ενός κλάδου που εξελίσσεται στην πολυπλοκότητα:
Τα σύνορα με τη Φιλοσοφία

Περίληψη στο τέλος του άρθρου

In the last quarter of the twentieth century, there has been a growing opposition to reductionism, driven by individual disciplines which however have given solutions to many practical problems of our times. Opposition grew along with a quest for unity of culture and the adoption of a complexity-based method. The movement was nurtured by Morin, Nicolescu and de Freitas who, in 1994, wrote and signed the *Charter of transdisciplinarity*. Complexity is therefore seen as an indispensable tool for the effective, harmonious, appropriate, timely and long lasting advancement of science. The old debate about basic and practical science has lost some of its appeal. Nephrology, born in the 1950s, is now charged with meeting the needs of more than 10% of the world population. It holds all the characteristics of a discipline born in the fertile world of complexity and continuously expanding into the boundaries of other disciplines. It is characterised by a unique exponential growth of generated information and by the capability of matching the challenges of big data algorithms and omics platforms. Chronic Kidney Disease (CKD) –a complex disease– is now amenable to cure.

Key words

CKD
Complexity
DKD
Nephrology
Omic techniques
Transdisciplinarity

1. INTRODUCTION

At the beginning of the 13th century in Europe, teaching was based on: (a) the *trivium* (literally the place where 3 roads meet), which included Grammar, Rhetoric and Dialectic and (b) the *quadrivium* (the place where 4 roads meet), which included Arithmetic, Geometry, Music and Astronomy, as described in the 7th book of Plato's *Republic* and represented the so-called liberal arts. These disciplines represented the basic curriculum for studying Theology, Medicine, Philosophy.

According to Basarab Nicolescu, there was "a big bang" and the number of disciplines increased to 8,000 in 2012. The fragmentation is erroneous, since our world is marked by the rapid advance of communications and a connected world is driven by complexity. "The new education has to invent new methods of teaching, founded on new logics. The old classical binary logic, that of "yes" and "no", i.e. the logic of the excluded middle, is no more valid in the context of complexity".[1]

The Webster Dictionary notes that "Discipline" is derived from the Latin *disciplina* meaning (a) teaching, learning, a subject that is taught; (b) a field of study; (c) training that moulds or perfects; (d) rules governing conduct or activity, and (e) control gained by enforcing obedience.

In Roman times, *Disciplina* was a minor goddess that was a personification of discipline and the patron of soldiers living at the Empire's borders.

We have discussed elsewhere "the process leading to birth, life, progress and death of disciplines and that one could well recount the history of humankind by analysing the lifespan of various disciplines".[2]

Le Goff pointed out that *"disciplines are often talked in an abstract way, as if they were ideas wandering around the world and possessing a scientific classification behind which are social organisations. Behind the division of knowledge there were the leaders of universities and schools who organised the discipline into subdivisions"*. He also stressed that scientists can protect their disciplines by participating in the debate on the media, after being appropriately trained in their use. The growing number of disciplines is directly linked to the schizophrenia of subdividing science into smaller and smaller tesserae, which is also a sign of the high subjectivity of the world's present inhabitants.[2,3] Ceruti pointed out that *"Specialties have generated new knowledge that however does*

not allow to solve multidimensional problems. The separation of disciplines makes us unfit to capture complexity. The fragmentation of thought allows experts and specialists to provide high performance within their areas and collaborate in non-complex sectors of knowledge. However, it makes us blind to inter- and retro-actions and circular causality".[4,5]

The history of science from Archilocus of Parsos (680–640 BC) to the Higgs boson (God's particle) adopted the method of reductionism for solving complex problems. Archilocus made a distinction between the fox that knows many things and the hedgehog that knows only one big thing, thus indicating that the fox is more creative and finds many tricks to escape hunters and dogs whereas the hedgehog knows one big thing which however in many occasions serves to save its life. The hedgehog has identified only one possible way and uses it in all occasions. In the same 7th century BC, Thales (born 636 BC) identified water as the universal principle.

2. THE QUEST FOR COMPLEXITY

In the last quarter of the last century, along with a quest for unity of culture, a growing opposition to specialisation emerged. A new method of teaching, not based on disciplines, but between disciplines and crossing disciplines was proposed; this adopted complexity. The method also flourished thanks to (a) the foundation in 1984 of the Santa Fe Institute in New Mexico, inspired by Murray Gellman and (b) the publication in 1994 of the *Charter of Transdisciplinarity,* signed by Lima de Freitas, Edgar Morin and Basarab Nicolescu. Complexity emerged from three main streams: cybernetics, general systems theory and dynamical system theory. It is now regarded as an indispensable tool for advancing science without losing the advantages of specialisation, which are of paramount importance for solving practical problems.

Disciplines play a great role in disseminating and furthering knowledge. "They are born –without aiming to eternity– in order to warrant the originality of the scientists who existed, exist and will exist in the future. Investigators attempt to achieve original findings with the hidden desire to be indicated as originators of ideas. Theirs is a battle to find an own role in the scientific enterprise, to be recognised; thus they scrape smaller niche disciplines and topics [...]. Disciplines however are like fractals; their boundary regions are zones where exchanges are wider than those occurring in the internal zones".[6,7]

We have now finally discovered the limits of reductionism; in the quest for transdisciplinarity, complexity has emerged. Thus for Morin we have "to substitute the method which drives to know by disjunction and reduction with a new method obliging us to know by distinction and conjunction" (Introduction to complex thinking). However, we have to be aware that we are not yet in the society of knowledge, but rather in the society where knowledge is fragmented, and consists of various *tesserae*, each separated from the others. Such separation does not allow us to bind them in order to understand the fundamental and global problems related to our personal lives as well as to our collective destinies".[8] So it means that "we have to do different things and we have to do things differently" and inject new blood into academia in order to create a new cadre of scientists.[9,10] Indeed Morin's efforts are devoted to introducing complexity in primary school.

3. PRESERVING THE BENEFITS OF REDUCTIONISM (SPECIALTIES) IN THE ERA OF COMPLEXITY

Specialisation may provide the best medical care. These benefits should be protected without renouncing the advantages of complexity. This can be achieved through a highly specialised workforce, meaning that the quality of students enrolled for university studies must necessarily increase.

This can be easily understood through the experience of a great leader of the industry, Tadahiro Sekimoto (1926–2007). As a young student, Sekimoto had prepared his Bachelor of Science under the mentorship of Kazuhiko Nishjijma, a candidate Nobel physicist, in 1960 and 1961. Sekimoto considered himself unfit for the academy so decided to work for NEC, where he became chairman of the board of directors.

In an interview to the *Asahi Evening News* on 9 April 1997, Sekimoto presented some rules for identifying the best employees at NEC, defining the "V" shaped collaborators. What did he mean? When you drill deeply in pursuit of your specialty the earth around the hole you dig crumbles on itself making drilling easier, allowing you to move further ahead in your specialty. A cross-sectional view of this hole resembles the letter V. They are the best specialists. However, success in one's profession requires the attitude of the ants climbing a bamboo tree. The tree has joints and ants cannot see what lies beyond the joint. To move ahead they have to move over the joint. When they clear it they run up against the next joint". Thus, complexity preserving the role of the best specialists is possible.[2–11] It is also telling about the quality of the people who must be enrolled. However, teaching complexity should start in primary school and

last until completion of high school. Once the process is in motion, all medical university students would be able to profit from the method.

4. NEPHROLOGY: A PROTOTYPE OF A DISCIPLINE GENERATED BY COMPLEXITY

Nephrology is a young discipline that effectively "entered the parlance of medicine in 1961", the year of the birth of its International Society. However, "it was the advent of maintenance dialysis that fuelled its growth after the 1970".[12,13]

Nephrology has been characterised[13] by "the exponential information overload being generated. The pattern began in the 1960s, has continued and been magnified by the specialty journals that have appeared since then. As shown in table 1, over the years since their inauguration, the number of pages in the leading journals in the field has doubled for some *(Journal of the American Society of Nephrology, JASN)*, quadrupled *(Kidney Int)* and quintupled *(Nephrology Dialysis Transplantation, NDT)* for others. But then, each of those journals has spawned new publications *(Nature Review Nephrology*, *Advances in Chronic Kidney Disease*, *NDT Plus*, and *Clinical JASN* additional information).

Systems biology is the last fruitful approach that drives the present progress of nephrology. Many omics databases have been published, which can be used for diagnostic purposes and to generate new hypotheses for clinical intervention as well as in research on IgA nephropathy and diabetic nephropathy.[14–16]

However, we have shown that the most successful steps of nephrology were driven by two main ideas: (a) the classification of Chronic Kidney Disease (CKD) based on the estimated glomerular filtration rate (eGFR) and (b) the identification of CKD and uraemia as systemic diseases.[17]

Table 1. Nephrology journals, showing the upwards trend in pages since their respective inauguration. Modified from Eknoyan.[13]

Year	Journal	Inaugural issue (pages)	June 2011 issue (pages)	% increase
1964	*Nephron*	72	219*	304
1972	*Kidney Int*	65	233	358
1981	*AJKD*	51	161	315
1986	*NDT*	63	309	490
1990	*JASN*	125	193	149

AJKD: American Journal of Kidney Diseases; Kidney Int: Kidney International; NDT: Nephrology Dialysis Transplantation; JASN: Journal of the American Society of Nephrology

*As of January 2003 Nephron has been divided into three separately edited sections, i.e., Clinical Practice, Experimental Nephrology and Physiology

5. CHRONIC KIDNEY DISEASE AND URAEMIA: SYSTEMIC DISEASES AMENABLE TO CURE

The complex and systemic nature of CKD was demonstrated by Zoccali et al.[18,19] Their studies revealed the limits of the reductionist approach. Thus, a systems biology approach was identified as potentially capable of exploring the pathophysiology of this systemic disease and unravelling critical pathways that can be targeted for CKD prevention and therapy. Those studies address the effects of CKD on (a) the energy-immunity link, (b) metabolism, bone and heart, (c) the gut-kidney link, (d) the lung-kidney link and (e) the link of the kidney with the nervous system.[18–20] However, recently real progress has been made, which may be conducive to the postponement of death and dialysis.[21–23] A new tool should also take into consideration "an age-adapted definition" of CKD.[24]

That means that nephrology is rooted in complexity, grows through interdisciplinarity; it will be continuously shaped by analysing big data and the use of algorithms. This will allow taking care of an increasing number of patients guided by guidelines emerging from complex analysis of a huge number of publications, which no nephrologist could read/analyse personally. eGFR is a strong tool derived from a complex process and we can soon expect other tools to explain the increase of cardiovascular death in patients with CKD as well to find the key to advance the now stagnant survival of kidney transplanted patients.

6. THE LINK WITH PHILOSOPHY

Science needs philosophy.[25] As nephrologists, we can remember that Empedocles of Acragas in the 5th century BC put forward a theory of a world made of air, water, fire, and earth, governed by love and hate. By observing body tissues, he strove to demonstrate that they consisted of four elements assembled at different mathematical ratios (*logos*). Blood was the most perfect tissue, because the ratio between elements is one. Bone was a very unusual tissue because it is made of 2 parts of earth, 2 parts of water, and 4 parts of fire.[26,27]

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ΠΕΡΙΛΗΨΗ

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Κατά το τελευταίο τέταρτο του 20ού αιώνα, υπήρξε μια αυξανόμενη αντιπαράθεση στον αναγωγισμό, που προωθήθηκε από μεμονωμένες επιστήμες, οι οποίες όμως έδωσαν λύσεις σε πολλά πρακτικά προβλήματα της εποχής μας. Η αντιπαράθεση αναπτύχθηκε μαζί με την αναζήτηση της ενότητας του πολιτισμού και της υιοθέτησης μιας μεθόδου με βάση την πολυπλοκότητα. Το κίνημα καλλιεργήθηκε από τους Morin, Nicolescu και de Freitas οι οποίοι, το 1994, έγραψαν και υπέγραψαν τον *Χάρτη της διεπιστημονικότητας*. Επομένως, η πολυπλοκότητα θεωρείται αναντικατάστατο εργαλείο για την αποτελεσματική, αρμονική, κατάλληλη, έγκαιρη και μακροχρόνια πρόοδο της επιστήμης. Η παλιά συζήτηση για τη βασική και την πρακτική επιστήμη έχει χάσει μέρος της γοητείας της. Η Νεφρολογία, που γεννήθηκε στη δεκαετία του 1950, είναι τώρα επιφορτισμένη με την κάλυψη των αναγκών άνω του 10% του παγκόσμιου πληθυσμού. Διαθέτει όλα τα χαρακτηριστικά μιας επιστήμης που γεννάται στον εύφορο κόσμο της πολυπλοκότητας και συνεχώς διευρύνεται στα όρια άλλων επιστημών. Χαρακτηρίζεται από μια μοναδική εκθετική ανάπτυξη των παραγόμενων πληροφοριών και από την ικανότητα αντιστοίχισης των προκλήσεων των μεγάλων αλγορίθμων δεδομένων και των ομικών πλατφορμών. Η χρόνια νόσος των νεφρών –μια σύνθετη ασθένεια– επιδέχεται πλέον θεραπεία.

Λέξεις ευρετηρίου: Διεπιστημονικότητα, CKD, DKD, Νεφρολογία, Ομικές τεχνικές, Πολυπλοκότητα

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