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A European Core Curriculum in Cariology: the knowledge base

P. Anderson[1], J. Beeley[2], P. Manarte Monteiro[3], H. de Soet[4], S. Andrian[5], B. Amaechi[6] and M.-C. D. N. J. M. Huysmans[7]

[1] Centre for Oral Growth and Development, Institute of Dentistry, QMUL, London, UK,
[2] School of Medicine, University of Glasgow, Glasgow, UK,
[3] Department of Medical Sciences, Faculty of Health Sciences, University Fernando Pessoa, Porto, Portugal,
[4] Department of Preventive Dentistry, Academic Centre for Dentistry Amsterdam, Amsterdam, The Netherlands,
[5] Department of Odontology and Periodontology, Faculty of Dental Medicine, University of Medicine and Pharmacy ''Gr. T. Popa'', Iaşi, Romania,
[6] Department of Comprehensive Dentistry, University of Texas Health Science Center at San Antonio, San Antonio, TX, USA,
[7] College of Dental Science, Radboud University Nijmegen Medical Centre, Nijmegen, The Netherlands

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Correspondence
Marie-Charlotte D. N. J. M. Huysmans
Department of Preventive and Restorative Dentistry
College of Dental Science
Radboud University Nijmegen Medical Centre
PO Box 9101
NL-6500 HB Nijmegen
The Netherlands
Tel: +31 24 361 6410
Fax: +31 24 354 0265
e-mail: m.c.d.n.j.m.huysmans@dent.umcn.nl
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Abstract

This paper is part of a series of papers towards a European Core Curriculum in Cariology for undergraduate dental students. The European Core Curriculum in Cariology is the outcome of a joint workshop of the European Organization for Caries Research (ORCA) together with the Association for Dental Education in Europe (ADEE), which was held in Berlin from 27 to 30 June 2010. This paper presents a closer look at the knowledge base as presented in the European Core Curriculum in Cariology. It comprises not only traditional basic sciences, such as anatomy and histology, but also emerging sciences such as molecular biology and nanotechnology and also fields such as behavioural sciences and research methodology. The different supporting competences are elaborated and explained. The problems of implementing a curriculum that truly integrates this foundation knowledge into the clinical teaching are discussed.

Introduction

This paper is part of a series of papers contributing towards a European Core Curriculum in Cariology for undergraduate dental students. The European Core Curriculum in Cariology is the outcome of a process starting in 2006 and culminating in a joint workshop of the European Organization for Caries Research (ORCA) together with the Association for Dental Education in Europe (ADEE), which was held in Berlin from 27 to 30 June, 2010 (Fig. 1). The scope of this paper is to present the Knowledge Base section of the European Core Curriculum in Cariology (1). This section was developed on the basis of international consensus on the current and future educational needs in the fields of Cariology and Disorders of Dental Hard Tissues.

Dentists graduating in the twenty-first century will be faced with a variety of new issues, including increasingly knowledge-enabled patients, more sophisticated technological-based therapies, minimally invasive dentistry approach and evidence-based dentistry. This will require that successful twenty-first century dentists have a fundamental understanding regarding the aetiology of caries disease process, skill sets to optimise the systems for early caries diagnostics in terms of possible clinical outcomes, sufficient basic science knowledge to carry out modern intervention or non-intervention procedures, and sufficient basic science required to critically review the literature and

Fig. 1. ORCA-ADEE workshop on the development of a European Core Curriculum in Cariology: Participants in working group I – The Knowledge Base. Marie-Charlotte Huysmans (Chair), Radboud University Nijmegen, The Netherlands; Hans de Soet (Co-chair), Academic Centre of Dentistry Amsterdam (ACTA), The Netherlands; Paul Anderson (rapporteur), Queen Mary University London, UK; Bennet Amaechi, University of Texas, USA; Sorin Andrian, University of Iasi, Romania; Josie Beeley, University of Glasgow, UK; Sophie Doméjean, University of Clermont-Ferrand, France; Jochen Klimek, University of Giessen, Germany; Chris Longbottom, University of Dundee, UK; Patricia Manarte, University Fernando Pessoa Porto, Portugal; Akos Nagy, University of Pécs, Hungary; Bente Nyvad, University of Aarhus, Denmark; Helen Whelton, University of Cork, Ireland.

documentation of treatment methods including the skills to interpret their evidence base.

Some of this foundation knowledge will be unique to cariology, whereas some will have commonality with other fields of the dental curriculum. The key role of curriculum designers is to ensure that all the required basic science knowledge described in this paper is included at some point in the undergraduate dental curriculum. Some of the required knowledge is similar to that for an understanding of other dental hard tissue disorders, such as erosion, and that connectivity is included in this paper.

The key teaching role is to demonstrate the clinical relevance of the particular knowledge imparted to the students. Thus, the knowledge base is not merely a list of facts, but the understanding of that knowledge as applied to the understanding of the development of the caries process, of the diagnosis and preventive and operative management of it, and of the way evidence-based practice can be an everyday reality in care for both the individual patient and the wider population.

There is a hierarchy of the basic knowledge and information in the caries process itself, from the basic chemical composition of enamel and the acid–base chemical dissolution of hydroxyapatite and the role of fluoride, for example, upwards through the impact of tooth morphology and biofilm behaviour, to the levels of the role of saliva and other aspects of the oral cavity, with the role of the environment and society at large in terms of diet and social deprivation, for example, at the 'top level'. There is also a parallel stream of information required for the prevention and management of caries, including dental materials, new caries diagnostic systems, new therapeutic treatment approaches, and the management of populations.

A closer look at the knowledge base

Development, growth and structures of the dental hard tissues

Fundamental knowledge is required of the basic anatomy and the developmental anatomy of the dental hard tissues and their surrounding structures at the macroscopic, microscopic and molecular/ionic levels. The molecular/ionic levels include the chemical composition and crystal lattice structure of hydroxyapatite, substituted apatites and other basic calcium phosphates, together with the differences between hydroxyapatite crystal structure in both enamel and dentine. This knowledge will also include the relevant physical chemistry of the orthophosphates, especially the effects of pH and calcium concentrations in adjacent solutions on hydroxyapatite crystal deposition and dissolution. This will highlight the role of salivary constituents in regulating calcium and phosphate ion equilibrium and in maintaining supersaturation conditions. Related is the role of fluoride in replacing hydroxyl ions and interacting with the crystal, thereby modifying its solubility by the formation of a thermodynamically more stable crystal; this is one of the mechanisms by which fluoride is a cariostatic agent. Knowledge of amelogenesis, dentinogenesis and related biomineralisation phenomena will introduce the student to protein control of hard tissue deposition and the complex mechanism by which teeth are formed. This will lead to an understanding of the diseases relating to the malformation of teeth including amelogenesis imperfecta and dentinogenesis imperfecta, resulting in higher caries susceptibilities in many of these individuals.

At the microscopic level, knowledge of how enamel crystals are arranged into a prism structure within enamel and within the complex structure of dentine will lead to the understanding of how transport in the interprismatic spaces influences caries progression. In dentine, knowledge is required of the architecture of the tubules, and how this impinges on the progression of dentinal caries, and treatments for, for example, dentine hypersensitivity. There must be sufficient knowledge to distinguish between enamel, dentine and bone at the microscopic level.

At the macroscopic level, knowledge of the differences in general morphology of individual teeth is required, together with the role of this in caries formation, for example, fissure caries, and the arrangement of the dentition within the jaws, including genetic and environmental factors affecting tooth morphology.

Aetiology, pathogenesis and modifying factors of dental caries and erosion

Caries is a biofilm-related disease, and the disease factors influencing caries progression require knowledge of the basic science of the disease nature of this process; they are quite different from erosion which is a tooth mineral dissolution by physical chemical processes caused simply by ambient fluids with a low pH. Caries is a tooth minerals destruction process initiated by acids formed during bacterial metabolism; therefore, knowledge of oral microbiology is a prerequisite to understanding caries. This will lead to a better awareness of the clinical significance of microbiology for the understanding of the caries process aetiology, and also the rationale for the design of therapeutic intervention.

There must also be a knowledge regarding the structure of the dental biofilm, the microbial composition and the changes in composition because of both changing environments and detection methods. Moreover, its metabolism in relation to caries formation should be addressed in detail. In plaque, some bacteria obtain energy by metabolising carbohydrate anaerobically to produce organic acids. Others metabolise amino acids to obtain energy, and along with bacteria, which degrade salivary urea, ammonia is produced which is basic and raises plaque pH. As long as these two processes are balanced, the biofilm will not be cariogenic. But in the presence of increased availability of fermentable carbohydrate, acidogenic bacteria will be at a biological advantage, the pH of the plaque will decrease thereby, increasing hydroxyapatite solubility and favouring the initiation of a carious lesion.

At the microscopic level, graduating dentists must be familiar with the effects of pH and calcium concentrations in the surrounding solutions, on the dynamic equilibrium balance between demineralisation and remineralisation, including subsurface demineralisation and white spot lesion formation. There needs to be knowledge of the chemical factors involved in the formation and progression of caries lesions including further destruction of the tooth resulting from bacterial invasion and the consequences of acid production together with degradation of the organic matrix by bacterial enzymes. Students must also be familiar with the architecture of caries lesions both in enamel and dentine and their progression.

At the macroscopic levels, students must be familiar with the appearance and terminology used to describe caries lesions and have an understanding of the reasons for the appearance of these lesions, including host responses. There should be an understanding of the environmental factors determining caries activities and the implications of other disease states.

A key factor in caries prevention is the role of saliva, both in a quantitative and in a qualitative sense. The rinsing and diluting capacity of saliva is closely related to its flow rate. Saliva not only contains buffers, which minimise changes in pH, it also contains calcium-binding proteins that act both as a calcium ion reserve and in maintaining saliva as a solution supersaturated with calcium phosphate, both favouring remineralisation. Salivary arginine containing peptides and urea is metabolised to ammonia by bacteria, also contributing to its anti-cariogenic properties. Xerostomia, resulting from systemic disorders, radiation therapy or prescription drugs are, therefore, a major cause of the onset of caries.

Diet and nutrition also play a key role in caries susceptibility, both in terms of metabolism of dietary constituents by oral micro-organisms, but also in the modification of the host oral flora.

Detection, assessment and diagnosis

Caries detection, assessment and diagnosis are fundamental for caries treatment, as the earlier the intervention the greater the likelihood of a successful outcome. There must be knowledge of the conventional visual and tactile methods of detection and assessment, together with modern techniques available to carry out early caries diagnosis and their limitations (e.g. caries detector dyes). For this purpose, the basic optical properties of dental hard tissues must be understood. Radiography as a widely used technique, requires an understanding of its physical and biological principles, together with an understanding of safety issues for both patient and clinician, and the ability to correlate the results with abnormalities in tooth structure are paramount. Findings must accordingly be integrated with the underlying basic science of the diagnostic methods being used. This knowledge will lead to a better understanding of the performance, reliability and the limitations of these methods. Moreover, the principles of evaluating diagnostic performance and clinical decision making are needed to contribute to informed treatment decisions.

Epidemiology and research methodology

Graduating dentists must have a basic understanding of statistical methods and sufficient knowledge of these to understand the basics of epidemiology, including sample means, non-parametric distributions, and statistical error in population studies.

They need to be familiar with common indices used to describe dental caries experience in a population and also with the prevalence and incidence (development) of the disease in their country/area.

They also need to be familiar with study design, blind/double blind studies, age/sex matching of populations, control groups, etc. This knowledge is required to understand the increasing number of evidence-based dentistry reports and population trends in dental caries.

Behavioural sciences

Whilst scientific and clinical knowledge of caries is fundamental to a core curriculum, patient behaviour is probably one of the most important contributory factors. Psychological skills, sociological aspects, communication skills and economic factors are all integrated in both the causes and prevention of caries. Students must be as confident with this aspect of the cause and prevention of caries as with the clinical aspects.

As dentists of today are also largely expected to work in interdisciplinary teams, working together with dental nurses, dental hygienists, other dentists with a special focus area and expertise, and specialists and physicians, knowledge about the theory and practice of teamwork and communication, and the organisation of oral care provision are also needed.

Prevention and management

The understanding of the basic science elements of caries prevention and management is essential if dentistry is to continue to be a profession rather than a technology. The basic biological principles of both surgical and non-surgical management of this disease must be soundly understood. New restorative and other treatment materials are rapidly emerging; to understand and critically assess their potential use, a firm grasp of basic chemistry is now essential. Nanotechnology is already to the fore; the dentist must be able to understand and assess the usefulness of this in relation to cariology. The future is likely to see the increased use of biologically based treatments, e.g. dentine regeneration factors, use of stem cells, gene therapy, as well as perhaps genetic aspects of caries risk and susceptibility. The proteomes of the oral cavity will be of increasing importance in the prevention and management of caries; 2010 saw the launch of the Human Proteome Project. New strategies for caries prevention and management are continually emerging. Probiotic strategies for control of dental biofilms are widely developing; recently, an antimicrobial treatment was developed that can be chemically programmed to seek out and kill a specific cariogenic bacteria. To be able to understand such strategies and their potential and limitations, the knowledge of current developments in the biological sciences must form part of the curriculum. This aspect of the basic sciences is integral to all parts of the dental curriculum, not just cariology.

How can this knowledge base be achieved? Implementation

To achieve the objectives identified in this paper, basic sciences must be properly integrated into the entire dental curriculum. It is widely accepted that integration is needed to make the learning more relevant and ultimately more available for use in a clinical context (2). Problem-based learning strategies are recognised as most appropriate for such integration, but varying levels of problem orientation may be suitable in different situations. Many schools have now moved from a pre-clinical and clinical format (where basic sciences were taught almost exclusively in the pre-clinical part of the curriculum and where students studied aspects relevant to cariology before they had even seen a carious lesion) to one where clinical work is introduced within the first 2 years and basic sciences extend into the clinical curriculum to varying extents.

Some dental schools have introduced a 'vertically integrated curriculum' in which students start their clinical work in the 2nd year. Basic science lectures are threaded around the clinical sessions for these later years. This ensures that the basic science delivery is relevant and topics introduced at the relevant point in the course. Whilst it is still essential that the fundamentals of basic science are taught shortly after admission to the undergraduate curriculum, ideally this subject should be properly integrated throughout the entire period of study, with material taught earlier in the course being reinforced as the course progresses and new material is introduced.

Achieving this is not easy, and most schools experience problems. There are few relevant course texts, basic scientists are usually research orientated, there is little contact between the basic scientists and their clinical colleagues, the course content is too often neither relevant nor interesting, few staff have the necessary expertise, and the students' perception of the course at the time of delivery is all too often poor.

Despite these problems, considerable progress has been made in recent years. Perhaps the most important of these is the revised edition of the Profile and Competences of the Graduating European Dentist – update 2009 (3): Domain 3 sets out the knowledge and understanding required in the basic biological, medical and clinical sciences, and the concepts included are fundamental to a European Curriculum in Cariology and the effect which this should have on school policy (including course design, allocation of resources and attitudes to these changes). In addition, teaching of basic sciences should be extended throughout the entire curriculum and included in the final examinations.

To facilitate these developments, informal meetings of basic science and clinical staff are needed, basic scientists must be involved in the planning and delivery of the curriculum and made to feel part of the teaching team. Ideally, basic scientists and clinicians should be involved in treatment planning seminars, and clinicians should be involved in basic science research. The 'meeting of minds' should be supported by relevant course texts, practical sessions and, increasingly important, e-learning. The 'new sciences', fields not by history and tradition related to dentistry, such as tissue engineering, molecular biology and nanotechnology, must be actively drawn into the dental curriculum (4).

However, many schools do not have in house basic science staff and this is a problem that is not easy to address. The dental course is an undergraduate degree course and the academic excellence of the basic science elements must be as good as that of the clinical subjects. Most dental schools are part of multi-faculty universities, which have both medical schools and basic science departments. Delivery of basic science teaching to dental students should be possible, in part by staff from these departments. But, joint teaching of dental students with medical students has often proved unsuccessful, because the needs of the two groups of students are different, both in terms of content and relevance to their course. Relevance relates not only to course content but to a depth of coverage which is relevant to dentistry, too. As the importance of the basic science base in the dental curriculum becomes increasingly recognised, it is hoped that schools will allocate more funding to invest in basic science staff, creating time and opportunity for them to interact with clinical staff, to maintain the excellence of the curriculum and to raise the research profile. Overall coordination must remain the remit of dental schools, and quality control maintained with the appropriate expertise, for example, by involvement of external examiners. However, there will continue to be variation from school to school in the detailed content and delivery of the cariology curriculum because of differing strengths, resources, facilities and expertise. Each school will need to deliver the best possible cariology course best suited to its own circumstances.

Concluding remarks

Different dental schools will approach the teaching of cariology in different ways and need to tailor the basic science components of the curriculum to match their particular emphasis. However, although the emphasis may be different, the core knowledge highlighted in this paper should be included to reach the overall goal: that the graduating dentist is competent at applying all the relevant foundation knowledge to enhance their ability to make the correct clinical decisions about prevention and management of caries and other dental hard tissue disorders.

Conflict of interest

All authors report no existing conflict of interest.

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