# Conference Paper
UQ:212894

## Evidence:

- Published in full (not abstract or extract) – need copy of full paper:

- Title of Paper:

- Title of Proceedings:

- Table of Contents:

- Preface
  - Introduction:

- Editor:

- Publisher:

- Conference Convenor

- ISSN/ISBN (if present):

- All dates referring to publication, printing and copyright, including date published online if applicable, and date conference was held:

- All authors of the paper:

- Evidence of UQ Author affiliation: By-line or other statement on the publication:

- Evidence of Peer Review of full paper (not just the abstract). Need one of:
  - statement in proceedings or
  - statement from editor or
  - copy of peer review assessment

- Proof of national or international significance (e.g. in Proceedings Title, in preface or list of affiliations of presenters)

- **Proof of Keynote or invited status and all other papers peer reviewed (if invoked)**
Review

A systematic review of the association between common single nucleotide polymorphisms and 25-hydroxyvitamin D concentrations

John J. McGrath\textsuperscript{a,b,c,*}, Sukanta Saha\textsuperscript{a}, Thomas H.J. Burne\textsuperscript{a,b}, Darryl W. Eyles\textsuperscript{a,b}

\textsuperscript{a} Queensland Centre for Mental Health Research, The Park Centre for Mental Health, Locked Bag 500, Richlands Q4077, Australia
\textsuperscript{b} Queensland Brain Institute, The University of Queensland, St Lucia Q4072, Australia
\textsuperscript{c} Department of Psychiatry, The University of Queensland, St Lucia Q4072, Australia

\textbf{ABSTRACT}

In order to appreciate the association between hypovitaminosis D and various adverse health outcomes, we require a thorough understanding of how common single nucleotide polymorphisms (SNPs) influence serum concentrations of 25-hydroxyvitamin D (25OHD). We undertook a systematic review of the literature in order to identify studies that examined 25OHD concentrations, and common SNPs. We found nine studies related to the vitamin D binding protein (group-specific component, GC), and five studies examining the vitamin D receptor (VDR). SNPs in a range of cytochrome P450 enzymes have also been examined in seven studies. Replicated findings have been found between 25OHD concentrations and (a) two SNPs in GC (rs4588, rs7041), (b) one SNP in VDR (rs10735810), and (c) one SNP in CYP27B1 (rs10877012). In light of these associations, it is feasible that optimal concentrations of 25OHD required to reduce disease outcomes may vary according to genotype. We speculate that recently identified U-shaped relationships between 25OHD concentrations and disease outcomes (i.e. increased risk at both high and low concentrations) may reflect a mixture of genotype-defined subgroups. Further research is required in order to clarify the genetic architecture underlying 25OHD serum concentrations, and to unravel the mechanisms of action responsible for these associations.

© 2010 Elsevier Ltd. All rights reserved.
1. Introduction

Over the last few decades there have been many studies reporting the association between vitamin D status and various health outcomes [1–4]. Recently, attention has turned to gene by environment interactions which could influence various vitamin D-related disorders [5–8]. For example, it is feasible that hypovitaminosis D is associated with adverse health outcomes only in the presence of particular variants of vitamin D-related genes. It is also feasible that individuals with particular vitamin D-related genotypes may require different health recommendations in order to optimize their vitamin D status. While there is growing recognition that recommendations for vitamin D sufficiency need revision [9], if vitamin D status is associated with genotype, then some individuals may require higher or lower serum concentrations of 25-hydroxyvitamin D (25OHD) in order to avoid particular adverse health outcomes. As the fields of nutrigenomics and personalized genomes mature [10–13], we need to anticipate the implications of these developments with respect to vitamin D-related health outcomes.

In order to appreciate the potential for gene by environment interactions linking vitamin D, genetic variation and disease outcomes, we must first have a clearer understanding of the genetic architecture underlying vitamin D status. Twin and family-based studies have previously confirmed that heritable factors have an architecture underlying vitamin D status. Twin and family-based studies, we must first have a clearer understanding of the genetic outcomes.

2. Materials and methods

The aim of this paper is to undertake a systematic review of the literature that has examined the association between common SNPs and serum 25OHD concentrations. Because the primary studies rarely reported the results in a fashion suitable for meta-analysis, the results are presented in a narrative format.

2.1. Identification of studies

A broad search string was used in MEDLINE in order to identify studies (all languages, all available years, search last completed 22.11.09) – ("vitamin D"[MeSH Terms] OR "vitamin D"[All Fields] OR "ergocalciferols"[MeSH Terms] OR "ergocalciferols"[All Fields]) OR ("calcifediol"[MeSH Terms] OR "calcifediol"[All Fields] OR "calcidiol"[All Fields]) OR (25-hydroxyvitamin D[All Fields]) OR 25-hydroxyvitamin D[All Fields] OR 25-hydroxyvitamin D[All Fields]) AND (("polymorphism" AND "single nucleotide"[MeSH Terms]) OR ("polymorphism"[All Fields] AND "single"[All Fields] AND “nucleotide”[All Fields]) OR “single nucleotide polymorphism”[All Fields] OR ("polymorphism" AND "single"[All Fields]) OR (SNP[All Fields] OR "SNP"[All Fields]) OR ("genome-wide association study"[MeSH Terms]) OR ("genome-wide association study"[All Fields]) OR ("genome-wide association study"[All Fields]) OR ("GWAS"[All Fields])

Potentially relevant papers were accessed in order to review the abstract and/or full text. Citations from relevant papers and review papers were scrutinized in order to locate additional relevant articles, book chapters, and conference papers and abstracts. In order to seek out additional material (i.e. the ‘gray literature’), we solicited the assistance of members of the research community by: (a) writing to the corresponding authors of all included papers in order to help identify additional publications, and (b) presenting a preliminary version of this paper at an international conference (14th International Workshop on Vitamin D, Brugge, Belgium, October 2009).
2.2. Eligibility criteria

The study must provide information about the association between variations in SNPs (or their derived haplotypes or related copy number variant) versus 25-hydroxyvitamin D$_3$ and/or 25-hydroxyvitamin D$_2$ (henceforth refereed to as 25OHD). All types of study designs were eligible, including community-based cohort studies, case–control studies and family-based studies (regardless of the nature of the health state of the cases or probands). This review is restricted to common SNPs, thus case reports of rare mutations associated with hereditary rickets were excluded.

Table 1
Summary table for included studies GC, VDR and CYP27B1.

<table>
<thead>
<tr>
<th>Study</th>
<th>Country</th>
<th>Sample size (sex)</th>
<th>Design (subject ascertainment)</th>
<th>Measurement of 25OHD</th>
<th>Genes of interest (total number of SNPs examined)</th>
<th>Gene and SNPs reported as significantly associated with 25OHD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abbas et al. [31]</td>
<td>Germany</td>
<td>Case = 1402, Control = 2,608 (F)</td>
<td>Breast cancer case–control (population based)</td>
<td>RIA (IDS)</td>
<td>GC (2)</td>
<td>rs4588 (Hap), rs7041 (Hap)</td>
</tr>
<tr>
<td>Ahn et al. [5]</td>
<td>USA</td>
<td>Case = 749, Control = 781 (M)</td>
<td>Prostate cancer case–control (community sampling)</td>
<td>RIA (Hearhand)</td>
<td>GC, CYP27B1, CYP27A1, CYP24A1, VDR, RXRA, RXRB, PPAR, NCOA1, NCOA2, NCOA3, SMAD3 (212)</td>
<td>rs7041, rs1155563, rs2282679, rs12512631</td>
</tr>
<tr>
<td>Benjamin et al. [36]</td>
<td>USA</td>
<td>1012 (P)</td>
<td>Cohort (population based)</td>
<td>RIA (DiaSorin)</td>
<td>Genome-wide association study (70,987) VDR (3)</td>
<td>NA</td>
</tr>
<tr>
<td>d’Alesio et al. [41]</td>
<td>France</td>
<td>185 (F)</td>
<td>Cohort (population based)</td>
<td>Competitive binding assay</td>
<td></td>
<td>VDR rs713516 (Hap), rs451035 (Hap)</td>
</tr>
<tr>
<td>Engelman et al. [27]</td>
<td>USA</td>
<td>229 (P)</td>
<td>Insulin resistance clinic-based family study</td>
<td>RIA (DiaSorin)</td>
<td>Genome-wide association study (300,139) GC, CYP27B1, VDR (30)</td>
<td>NA</td>
</tr>
<tr>
<td>Engelman et al. [18]</td>
<td>USA</td>
<td>1,530 (P)</td>
<td>Insulin resistance family study (clinic based)</td>
<td>RIA (DiaSorin)</td>
<td></td>
<td>GC rs4588, rs7041, rs10783219</td>
</tr>
<tr>
<td>Fang et al. [39]</td>
<td>The Netherlands</td>
<td>1317 (P)</td>
<td>Cohort (population based)</td>
<td>RIA (IDS)</td>
<td>GC (2)</td>
<td>rs4588 (Hap), rs7041 (Hap)</td>
</tr>
<tr>
<td>Fu at al. [28]</td>
<td>Canada</td>
<td>80 (P)</td>
<td>Cohort sample</td>
<td>RIA (DiaSorin)</td>
<td>GC (1)</td>
<td>rs4588 (Hap)</td>
</tr>
<tr>
<td>Fu et al. [40]</td>
<td>Canada</td>
<td>98 (P)</td>
<td>Cohort (clinic and community sample)</td>
<td>RIA (DiaSorin)</td>
<td>GC (2)</td>
<td>rs4588 (Hap)</td>
</tr>
<tr>
<td>Hypponen et al. [37]</td>
<td>UK</td>
<td>7,288 (P)</td>
<td>Cohort (population based)</td>
<td>RIA (IDS)</td>
<td>CYP27B1 (1)</td>
<td>rs10877012, rs10735810, rs70351842, rs464653, rs10741657</td>
</tr>
<tr>
<td>Kurylowicz et al. [32]</td>
<td>Poland</td>
<td>Case = 332, Control = 185 (P)</td>
<td>Graves disease case–control (clinic based)</td>
<td>NA</td>
<td>GC (3)</td>
<td>rs4588</td>
</tr>
<tr>
<td>Orton et al. [34]</td>
<td>Canada</td>
<td>198 (P)</td>
<td>Multiple sclerosis twin-based sample (register based)</td>
<td>RIA (DiaSorin)</td>
<td>VDR, CYP27B1 (35)</td>
<td>VDR rs10735810, CYP27B1, CYP2RA, CYP24A1, rs1246536, rs10741657</td>
</tr>
<tr>
<td>Ramos-Lopez et al. [35]</td>
<td>Germany</td>
<td>609 (p)</td>
<td>Diabetes, clinic-based family study</td>
<td>RIA (DiaSorin)</td>
<td>CYP2R1 (5)</td>
<td>rs4588</td>
</tr>
<tr>
<td>Ramos-Lopez et al. [33]</td>
<td>Germany</td>
<td>Case = 222, Control = 104 (P)</td>
<td>Gestational diabetes case–control (clinic and community based)</td>
<td>RIA (DiaSorin)</td>
<td>CYP27B1, CYP2R1 (2)</td>
<td>rs10877077, rs10735810, CYP2R1, CYP2RA, CYP24A1, rs1246536, rs10741657</td>
</tr>
<tr>
<td>Sinotte et al. [38]</td>
<td>Canada</td>
<td>741 (F)</td>
<td>Cohort (community based)</td>
<td>RIA (DiaSorin)</td>
<td>GC (2)</td>
<td>rs4588, rs7041</td>
</tr>
<tr>
<td>Smolders et al. [29,30]</td>
<td>The Netherlands</td>
<td>Case = 212, Control = 289 (P)</td>
<td>Multiple sclerosis case–control study (clinic based)</td>
<td>RIA (IDS)</td>
<td>VDR (3)</td>
<td>rs10735810, rs10766197</td>
</tr>
<tr>
<td>Wjst et al. [24]</td>
<td>Germany and Sweden</td>
<td>872 (P)</td>
<td>Asthma family study (clinic based)</td>
<td>RIA (IDS)</td>
<td>GC, VDR, CYP27B1, CYP2R1, CYP24A1, IL4R, IL10, CARD15, IL12RB1, SPP, ADRE2, IL12B, RXRA (96)</td>
<td>CYP2R1 rs10766197, CYP24A1 rs2244719, rs2296241, rs17219315</td>
</tr>
</tbody>
</table>

P = persons, M = male, F = female, RIA = radioimmunoassay, NA = not available, and Hap = haplotype based on the shown SNPs
2.3. Data synthesis

Data were extracted from each paper and compiled for each SNP. SNPs were grouped according to proximity to protein-coding genes. We report unadjusted significant associations ($p < 0.05$), as reported by the original paper. Preliminary assessment of the papers indicated that few studies provided sufficient information to allow for pooled analysis. As a result, we restricted our analysis to simple descriptive counts of occasions where specific SNPs were found to be significantly associated with 25OHD concentrations. Where there were sufficient unambiguous data to report on more details of the association (e.g. which allele was associated with high or low 25OHD concentrations), we reported this in a narrative fashion.

3. Results

The Medline search identified 197 articles, of which only nine met the inclusion criteria. Seven additional references were identified via citation checking. Two conference abstracts were identified after contact with authors [27,28]. There were several studies that reported on interactions between various SNPs, 25OHD concentrations and disease outcomes, but did not provide the necessary information on the specific association between the SNPs and 25OHD.

We found eighteen papers (reporting on seventeen studies) that included statistical analysis between SNPs in candidate genes and 25OHD concentrations (note – two papers on the VDR are based on the same subjects and are thus counted as only one study [29,30]). Details of these studies are summarized in Table 1. Five of the studies were based on case–control studies [5,29–33]. The cases included individuals with breast or prostate cancer, Graves disease, multiple sclerosis and gestational diabetes. Family- and twin-based studies were also identified – these were based on probands with insulin resistance, multiple sclerosis, diabetes or asthma [18,24,27,34,35]. The remainder of the studies were based on community- or population-based cohorts, including two from large, well described cohorts (i.e. Framingham Heart study [36] and the 1958 UK birth cohort [37]). The sample size ranged from 80 to 7288 subjects.

Two genome-wide association studies were identified [27,36]. The remainder of the included studies examined SNPs in a total of 20 different genes. Nine studies examined SNPs in the vitamin D binding protein (group-specific component, GC [5,24,27,28,31,32,38–40]). The most consistent findings emerged for rs4588 and rs7041 (or derived haplotypes from these two SNPs) (see Supplementary Tables 1a and 1b). However, three other SNPs in this gene were also significantly associated with 25OHD concentrations [5]. With respect to the rs4588 findings, the pattern of association was consistent across all studies, with the C allele (the ancestral allele, 60% in Caucasian European Utah samples) found to be significantly associated with higher concentrations of 25OHD. With respect to rs7041, the pattern of findings was also consistent, with the T allele (the ancestral allele, 41% in CEU populations) found to be significantly associated with lower 25OHD concentrations, however none were found to be significantly associated in more than one study (Supplementary Tables 4–6).

Based on the Framingham study [36], there were no SNPs that met genome-wide significance level when adjusted for multiple comparisons. However, the top hit was found for rs10485165 (on Chromosome 1, no known function or adjacent protein-coding gene). Recently, preliminary results from a genome-wide association study were published in abstract form [27]. This study reported two SNPs with unknown function on chromosome 1 and a third on chromosome 9 that were highly significantly associated with 25OHD concentrations (details not available).

4. Discussion

Two SNPs in the vitamin D binding protein gene (GC; rs4588, rs7041) have repeatedly been found to be significantly associated with 25OHD concentrations. These studies are consistent with other studies based on protein isoforms of this binding protein [25,42]. There is also some inconsistent support for one SNP in the vitamin D Receptor gene (VDR; rs10735810), and one SNP in the enzyme that converts the storage form of the vitamin (25OHD) to the active ligand 1,25OHD (CYP27B1; rs10877012). While the body of evidence is still incomplete, there is now robust evidence demonstrating that common variations in at least some candidate genes influence vitamin D status. The key questions now relate to: (a) how variations in the genotype interact with vitamin D status to influence health outcomes, and (b) whether individuals with genotypes known to influence vitamin D status may require particular (‘personalized’) recommendations with respect to optimizing vitamin D status in order to minimize adverse health outcomes.

5. Vitamin D binding protein

Concerning the vitamin D binding protein (GC), it has been suggested that the mechanism of action linking variations in this protein and 25OHD levels could reflect the differential affinity of GC isoforms for 25OHD and 1,25OHD [43]. If we assume that only the free fractions of 25OHD and 1,25OHD are able to enter the cell, then variants of GC that have higher affinity for the ligand will result in a lower free fraction and presumably diminished access to target sites. However, clinical assays of 25OHD measure total concentrations, which includes both the GC-bound and free fraction [44]. It is feasible that standard measures of (total) 25OHD used in epidemiological studies could provide misleading assessments of the relative amount of free (and thus available) 25OHD.

In addition, plasma levels of the binding protein itself are known to vary according to GC types [25]. There is also evidence of differential 25OHD concentrations in response to oral supplementation with cholecalciferol (the precursor of 25OHD) by GC genotypes, further suggesting that the type of GC protein influences 25OHD concentrations in a non-linear fashion [40]. Recent studies based on
transgenic mice lacking the GC protein have suggested that other proteins are also involved in the transport of 25OHD and 1,25OHD in the circulation [45]. In summary, while the evidence linking variants in GC with 25OHD is strong, the underlying mechanism of action remains unclear.

Apart from providing transport around the circulatory system, it is also feasible that variation in GC could influence the facilitated transport of the bound GC and 25OHD into the cell, or back from the renal tubule, thus also disrupting outflow mechanisms. Thus far, only megalin and cubilin have been identified for the retrieval of GC-bound 25OHD from the distal renal tubule [46,47]. There is uncertainty about the potential intracellular-transfer of protein-bound 25OHD or 1,25OHD in many other target tissues [48,49]. However, it is feasible that facilitated transport of the GC-bound 25OHD or 1,25OHD occurs across a range of compartments (e.g. blood brain barrier, placenta), and into cells (e.g. neurons, breast cancer cells). To date, we are not aware of any studies that have examined SNPs in this family of transporting proteins and 25OHD concentrations.

5.1. Vitamin D receptor and CYP27B1

With respect to the VDR, the Fok1 polymorphism (rs10735810) changes the VDR translation initiation site and alters functional properties of the receptor [50,51]. Differential activity of the receptor could alter the pattern of vitamin D-mediated gene activation, and thus impact on a wide range of CYP450 enzymes involved in the production and elimination of 25OHD. While there is robust evidence linking polymorphisms in the VDR and increased risk of a range of adverse health outcomes such as cancer [7], it is not yet clear how SNPs in this gene influence 25OHD concentrations.

While two studies reported an association between the rs1087701 SNP in CYP27B1, the direction of the finding did not appear to be consistent. As with the findings with respect to GC and supplementation [40], this may also reflect non-linear relationships between CYP27B1 and 25OHD concentrations. Hypponen et al. reported that their finding linking rs1087701 and 25OHD varied in strength according to season [37] (a finding reminiscent of the observation that twin-based heritability estimates also vary according to season of testing [15]). A study examining multiple sclerosis in twins has reported that two additional SNPs in CYP27B1 were associated with 25OHD concentrations [34], however these particular SNPs (rs703842, rs4646536), were not replicated in other studies [5,18,24]. Variations in this gene that reduce the efficiency of the hydroxylation of 25OHD to 1,25OH could lead to a scenario where serum 25OHD concentrations appear normal or even high, but the concentration of the active ligand 1,25OHD may be suboptimal. In other words, some individuals may have mild ‘vitamin D resistance’, but lack a gross rickets-like phenotype.

5.2. Caveats

Many of the studies included in this systematic review are based on small or moderate sized groups. These lack sufficient power to detect true but small effect size relationships. Unfortunately, few papers reported the results in a fashion suitable for meta-analysis (e.g. quantitative analysis, precise nature of the alleles associated with high versus low 25OHD). Several of the papers were based on case-control studies, thus it is feasible that disease-related SNPs may confound the interpretation of the results (e.g. SNPs that are causality related to the disease but not to 25OHD may appear to be associated with 25OHD status as a consequence of a disease-related decrease in outdoor activity). Publication bias may also be an issue, as studies that did not find significant associations between the variables of interest may be less likely to be published.

5.3. Implications for future research

We can expect more genome-wide association studies related to 25OHD concentrations to be published as the technology becomes widely available [52]. These high-throughput studies may reveal previously unsuspected pathways impacting on 25OHD. While outside the scope of the current review, a genome-wide linkage study based on asthma pedigrees has examined the association between 364 autosomal microsatellite markers and 25OHD concentrations [14]. This study commented on two potentially interesting findings, with markers associated with TGFA (transforming growth factor alpha) and CYP26B1, a cytochrome P450 which could influence vitamin D metabolism. A study based on the Framingham Offspring study (n=1762) examined genome-wide linkage between 601 microsatellite markers and 25OHD [16]. The highest LOD score (1.16) was identified on chromosome 14 at 56 CM, however this finding did not achieve genome-wide significance. High-throughput technology will allow the exploration of candidate genes that have not yet been examined, and next-generation sequencing platforms will assist with the identification of rare variants, and eventually assess the entire genome for variants associated with 25OHD. Apart from the promises of this future technology, there are some research questions that could be examined with available technology. For example, SNPs that influence skin colour [53], would also be expected to influence 25OHD. SNPs in genes related to cholesterol production could also potentially impact on the availability of precursor of pre-vitamin D. While a small set of CYP450 enzymes have been examined to date, there are probably other related cytochrome P450 enzymes that can also influence 25OHD levels (e.g. CYP3A4 [54]).

Other levels of complexity need to be considered when unravelling the genetic architecture of 25OHD. This review has focussed on the storage form 25OHD, but the functional half-life of this molecule will be influenced by SNPs that influence the concentration of the active ligand 1,25OHD. To date, SNPs related to several genes have been linked to concentration of 1,25OHD, including DAB1 [27], IL10, IL12B and CYP24A1 [24]. Isoforms of the GC protein have also been linked 1,25OHD concentrations [25]. It is known that key enzymes involved in the production of 1,25OHD have splice variants [55]. While it is not yet known if these variants are associated with common SNPs, some of these splice variants have important functional implications, which could vary between tissue types and across the lifespan. Similarly, as we learn more about enhancers and regulatory regions of vitamin D–related genes, variations in these key regions will warrant closer scrutiny [56,57]. SNPs may also influence epigenetic markings, which will be of increasing interest in years to come – recently genes involved in vitamin D production and elimination in the placenta have been noted to be epigenetically modified [58]. Finally, when assessing the relationship between 25OHD concentrations and disease outcomes, genetic variation may be relevant in an organ- or disease-specific fashion. For example, SNPs that impact on vitamin D response elements may only influence cell activity in organs that actively express that gene. These features will need to be considered in order to fully understand the relationship between vitamin D and disease outcomes.

5.4. Genetic variation and non-linear exposure-risk relationships

Understanding the genetic factors influencing 25OHD production, elimination, and transport may help us better understand results from several recent studies. Epidemiological studies have recently identified U-shaped exposure-risk relationships between
25OHD concentrations and disease outcomes (e.g. IgE [37], prostate cancer [59], low birth weight [60]). These studies have found that both low and high concentrations of 25OHD are associated with disease outcomes (compared to middle range concentrations). Theories about the mechanism of action underpinning U-shaped relationships are now being generated. For example, it has been suggested that 25OHD itself may be more biologically active than previously thought [61], and that this storage form of the molecule may influence health outcomes in a non-linear fashion. Alternatively, there could be unexpected lags in the enzymatic capacity to deal with widely fluctuating seasonal concentrations of 25OHD (e.g. enzymes ‘tuned’ to low 25OHD during winter months may be ill-equipped to deal with higher concentrations that follow in the summer months) [62].

We speculate that the U-shaped relationship found between 25OHD concentrations and disease outcomes could also represent a mixture of subgroups that differ in key components of the vitamin D-related regulatory pathways. For example, it is feasible that some subgroups have high 25OHD serum concentrations but low intracellular 1,25(OH)2 serum concentrations (e.g. certain SNPs may reduce the efficiency of CY27B1 gene). These individuals may be at an increased risk of vitamin D-related adverse health outcomes, but appear to have higher concentrations of 25OHD due to reduced ‘outflow’ mechanisms. The presence of a subgroup of such individuals in case–control studies could contribute to the upper range of U-shaped exposure-risk relationships.

Failure to stratify case–control samples according to these mislabeling subgroups could lead to inappropriate public health recommendations. For example, public health bodies may recommend mid-range 25OHD concentrations in order to avoid the apparently increased risk of both low and high ends of the U-shaped exposure-risk relationship. However, the subgroup with genotypes that result in mild ‘vitamin D resistance’ (who may appear in the upper range of the U-shaped relationship) may actually require additional supplementation in order to optimize vitamin D-related physiology. Understanding the association between SNPs and 25OHD concentrations may help us address the various (non-exclusive) hypotheses that have been proposed to explain U-shaped relationships identified in vitamin D-related studies.

6. Conclusions

Mindful that our knowledge of the genetic mechanisms underpinning vitamin D metabolism is incomplete, we need to build plausible models upon which we can make predictions about how genetic variation influence vitamin D status. Further research is required in order to clarify the genetic architecture of 25OHD concentrations, and to unravel the mechanisms of action responsible for these associations.

Conflicts of interest

The authors have no conflicts of interest to declare.

Acknowledgements

We are grateful to the researchers who helped us to identify studies for inclusion in this review. JM designed and coordinated the overall study. JM and SS extracted the data from the primary articles. TB, JM and DE reviewed the data and all authors were involved in the writing and final approval of the manuscript.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.jsbmb.2010.03.073.

References


The Journal of Steroid Biochemistry and Molecular Biology

Copyright © 2010 Elsevier Ltd. All rights reserved

Publication History:
Formerly known as Journal of Steroid Biochemistry

Volume 121, Issues 1-2, Pages 1-478 (July 2010)
Proceedings of the 14th Vitamin D Workshop
Edited by Anthony W. Norman, Roger Bouillon and Jerzy Adamski

Volume 121, Issues 3-5
pp. 479-640 (August 2010)
Steroid profiling and analytics: going towards Sterome

Chemistry of vitamin D steriods

Volume 122 (2010)
Volume 121 (2010)
Volume 120 (2010)
Volume 119 (2010)
Volume 118 (2010)
Volume 117 (2009)
Volume 116 (2009)
Volume 115 (2009)
Volume 114 (2009)
Volume 113 (2009)
Volume 112 (2008)
Volume 111 (2008)
Volume 110 (2008)
Volume 109 (2008)
Volume 108 (2008)
Volume 107 (2007)
Volume 106 (2007)
Volume 105 (2007)
Volume 104 (2007)
Volume 103 (2007)
Volume 102 (2006)
Volume 101 (2006)
Volume 100 (2006)
Volume 99 (2006)
Volume 98 (2006)
Volume 97 (2005)
Volume 96 (2005)
Volume 95 (2005)
Volume 94 (2005)
Volume 93 (2005)
Volume 92 (2004)
Volume 91 (2004)
Volumes 89 - 90 (2004)
Volume 87 (2003)

No prev art. 1 - 100 of 107 Next ►
A molecular description of ligand binding to the two overlapping binding pockets of the nuclear vitamin D receptor (VDR): Structure-function implications
Original Research Article
Pages 98-105
Mathew T. Mizwicki, Danusa Menegaz, Sepideh Yaghmaei, Helen L. Henry, Anthony W. Norman

The transcription factors Snail1 and Snail2 repress vitamin D receptor during colon cancer progression
Original Research Article
Pages 106-109
María Jesús Larriba, Félix Bonilla, Alberto Muñoz

VDR microRNA expression and epigenetic silencing of vitamin D signaling in melanoma cells
Original Research Article
Pages 110-113

Heat shock protein 90 interacts with vitamin D receptor in human leukemia cells
Original Research Article
Pages 114-116
Ewa Marcinikowska, Elżbieta Gocek

Growth, calcium status and vitamin D receptor (VDR) promoter genotype in European children with normal or low calcium intake
Original Research Article
Pages 117-120

Cloning the human vitamin D receptor into the pTwin-1 expression vector
Original Research Article
Pages 121-123
Elaine D. Collins, Aileen Espinoza, Lily Thao-Nhi Le, Mallory Kato

Theoretical study of molecular mechanism of binding TRAP220 coactivator to Retinoid X Receptor alpha, activated by 9-cis retinoic acid
Original Research Article
Pages 124-129
Mateusz Kurcinski, Andrzej Kolinski

Gene regulation by 1α,25(OH)2vitamin D3

Emerging regulatory paradigms for control of gene expression by 1,25-dihydroxyvitamin D3
Original Research Article
Pages 130-135
J. Wesley Pike, Mark B. Meyer, Melissa L. Martowicz, Kathleen A. Bishop, Seong Min Lee, Robert D. Nerenz, Paul D. Goetsch

Genome-wide analysis of the VDR/RXR cistrome in osteoblast cells provides new mechanistic insight into the actions of the vitamin D hormone
Original Research Article
Pages 136-141
Mark B. Meyer, Paul D. Goetsch, J. Wesley Pike

The genes encoding cytokines IL-2, IL-10 and IL-12B are primary 1α,25(OH)2D3 target genes
Original Research Article
Pages 142-145
Juha M. Matilainen, Antti Räsänen, Petra Gynther, Sami Väisänen

22S-Butyl-1α,24R-dihydroxyvitamin D3: Recovery of vitamin D receptor agonistic activity
Original Research Article
Pages 146-150
Yuka Inaba, Makoto Nakabayashi, Toshimasa Itoh, Nobuko Yoshimoto, Teikichi Kura, Nobutoshi Ito, Masato Shimizu, Keiko Yamamoto

Human breast tumor slices: A model for identification of vitamin D regulated genes in the tumor microenvironment
Original Research Article
Pages 151-155
34 Recruitment and subnuclear distribution of the regulatory machinery during 1α,25-
dihydroxy vitamin D3-mediated transcriptional upregulation in osteoblasts Original Research Article
Pages 156-158
Gloria Arriagada, Berta Henriquez, Daniel Moena, Paola Merino, Cinthya Ruiz-Tagle, Jane B. Lian, Gary S. Stein, Janet L. Stein, Martin Montecino

35 Rapid responses to 1α,25(OH)2 vitamin D3

36 Photoprotection by 1α,25-dihydroxyvitamin D and analogs: Further studies on mechanisms and implications for UV-damage Original Research Article
Pages 164-168

37 Caveolae and caveolin-1 are implicated in 1α,25(OH)2-vitamin D3-dependent modulation of Src, MAPK cascades and VDR localization in skeletal muscle cells Original Research Article
Pages 169-175
Claudia Buitrago, Ricardo Boland

38 Proficiency testing of 25-Hydroxyvitamin D (25-OHD) assays Original Research Article
Pages 176-179

39 Exogenous versus endogenous recovery of 25-hydroxyvitamins D2 and D3 in human samples using high-performance liquid chromatography and the DiaSorin LIAISON Total-D Assay Original Research Article
Pages 180-182
Ronald L. Horst

40 Mechanisms involved in vitamin D mediated intestinal calcium absorption and in non-classical actions of vitamin D Original Research Article
Pages 183-187
Sylvia Christakos, Puneet Dhawan, Darje Ajbade, Bryan S. Benn, Jingjing Feng, Sineh S. Joshi

41 Myocardial effects of VDR activators in renal failure Original Research Article
Pages 188-192
Masahide Kanduchi, Hiroshi Nakamura, Masanori Tokumoto, Jane Finch, Jeremiah Morrissey, Helen Liapis, Eduardo Slatopolsky

42 Vitamin D inhibition of TACE and prevention of renal osteodystrophy and cardiovascular mortality Original Research Article
Pages 193-198
Adriana Dusso, Maria Vitoria Aciutincon, Jing Yang, Masanori Tokumoto

43 Vitamin D and primary hyperparathyroidism (PHPT) Original Research Article
Pages 204-207
Jean-Claude Souberbielle, Emilie Maury, Gérard Friedlander, Catherine Cormier

44 A novel nonsecosteroidal VDR agonist (CH5036249) exhibits efficacy in a spontaneous benign prostatic hyperplasia beagle model Original Research Article
Pages 208-211
Cecylia Tukaj, Piotr Trzonkowski, Maria Kukla, Anna Hallmann, Stefan Tukaj

45 Increased migratory properties of aortal smooth muscle cells exposed to calcitriol in culture Original Research Article
Pages 212-215
Cecylia Tukaj, Piotr Trzonkowski, Michal Pikula, Anna Hallmann, Stefan Tukaj
46  24R,25-Dihydroxyvitamin D3 [24R,25(OH)2D3] controls growth plate development by inhibiting apoptosis in the reserve zone and stimulating response to 1α,25(OH)2D3 in hypertrophic cells  
Original Research Article  
Pages 212-216  
B.D. Boyan, J. Hurst-Kennedy, T.A. Denison, Z. Schwartz  
Show preview |  
PDF (601 K) | Related articles | Related reference work articles

47  Interalleation of parathyroid hormone and vitamin D metabolites in adolescents from the UK and The Gambia  
Original Research Article  
Pages 217-220  
Show preview |  
PDF (397 K) | Related articles | Related reference work articles

Immunology

48  Human T lymphocytes are direct targets of 1,25-dihydroxyvitamin D3 in the immune system  
Original Research Article  
Pages 221-227  
Femke Baeke, Hannelie Kor, Lot Overbergh, Evelyne van Etten, Annemieke Verstuyf, Conny Gysemans, Chantal Mathieu  
Show preview |  
PDF (538 K) | Related articles | Related reference work articles

49  1α-Hydroxylase and innate immune responses to 25-hydroxyvitamin D in colonic cell lines  
Original Research Article  
Pages 228-233  
Venu Lagishetty, Rene F. Chun, Nancy Q. Liu, Thomas S. Lisse, John S. Adams, Martin Hewison  
Show preview |  
PDF (546 K) | Related articles | Related reference work articles

Vitamin D and bone

50  Vitamin D as an inducer of cathelicidin antimicrobial peptide expression: Past, present and future  
Review Article  
Pages 234-238  
John H. White  
Show preview |  
PDF (258 K) | Related articles | Related reference work articles

51  Developmental vitamin D3 deficiency induces alterations in immune organ morphology and function in adult offspring  
Original Research Article  
Pages 239-242  
Louise Harvey, Thomas H.J. Burne, John J. McGrath, Darryl W. Eyles  
Show preview |  
PDF (311 K) | Related articles | Related reference work articles

52  Regulatory T cell function correlates with serum 25-hydroxyvitamin D, but not with 1,25-dihydroxyvitamin D, parathyroid hormone and calcium levels in patients with relapsing remitting multiple sclerosis  
Original Research Article  
Pages 243-246  
Joost Smolders, Paul Menheere, Mariëlle Thewissen, Evelyn Peelen, Jan Willem Cohen Tervaet, Raymond Hupperts, Jan Damselaers  
Show preview |  
PDF (373 K) | Related articles | Related reference work articles

53  Immune-modifying properties of topical vitamin D: Focus on dendritic cells and T cells  
Original Research Article  
Pages 247-249  
Shelley Gorman, Melinda A. Judge, Prue H. Hart  
Show preview |  
PDF (216 K) | Related articles | Related reference work articles

54  Severity of experimental autoimmune encephalomyelitis is unexpectedly reduced in mice born to vitamin D-deficient mothers  
Original Research Article  
Pages 250-253  
Diana Andrea Fernandes de Abreu, El Chérif Ibrahim, José Boucraut, Michel Kheshtchatskyy, François Faron  
Show preview |  
PDF (365 K) | Supplementary content | Related articles | Related reference work articles

55  CYP24A1-deficient mice as a tool to uncover a biological activity for vitamin D metabolites hydroxylated at position 24  
Original Research Article  
Pages 254-256  
René St-Arnaud  
Show preview |  
PDF (182 K) | Related articles | Related reference work articles

56  Disruption of Pdia3 gene results in bone abnormality and affects 1α,25-dihydroxyvitamin D3-induced rapid activation of PKC  
Original Research Article  
Pages 257-260  
Yun Wang, Jiaxuan Chen, Christophe S.D. Lee, Alexandr Nizkorodov, Kelsie Riemenschneider, David Martin, Sharon Hyzy, Zvi Schwartz, Barbara D. Boyan  
Show preview |  
PDF (293 K) | Related articles | Related reference work articles

57  Comparison of the effects of eldecalcitol and alfalcacidol on bone and calcium metabolism  
Original Research Article  
Pages 261-264  
Toshio Matsumoto, Toshiyuki Takano, Shinji Yamakido, Fumiaki Takahashi, Naoki Tsuji  
Show preview |  
PDF (418 K) | Related articles | Related reference work articles
<table>
<thead>
<tr>
<th>Page</th>
<th>Title</th>
<th>Authors</th>
<th>Related links</th>
</tr>
</thead>
<tbody>
<tr>
<td>58</td>
<td>Vitamin D analogs induce lipoxygenase mRNA expression and activity as well as reactive oxygen species (ROS) production in human bone cells</td>
<td>D. Somjen, S. Katzburg, E. Knoll, O. Sharon, G.H. Posner, N. Stem</td>
<td>Show preview</td>
</tr>
<tr>
<td>59</td>
<td>Effect of the supplementation of dietary rich phytoestrogens in altering the vitamin D levels in diet induced osteoporotic rat model</td>
<td>S. Chennaiah, V. Vjalyalakshmi, C. Suresh</td>
<td>Show preview</td>
</tr>
<tr>
<td>60</td>
<td>Failure of alphacalcidol (1α-hydroxyvitamin D$_3$) in treating nutritional rickets and the biochemical response to ergocalciferol</td>
<td>M. Kogawa, P.H. Anderson, D.M. Findlay, H.A. Morris, G.J. Atkins</td>
<td>Show preview</td>
</tr>
<tr>
<td>62</td>
<td>Eldecalcitol is less effective in suppressing parathyroid hormone compared to calcitriol in vivo</td>
<td>Hassanali Vatanparast, Mona S. Calvo, Timothy J. Green, Susan J. Whiting</td>
<td>Show preview</td>
</tr>
<tr>
<td>63</td>
<td>Discordant effects of vitamin D deficiency in trabecular and cortical bone architecture and strength in growing rodents</td>
<td>P.R. von Hurst, W. Stonehouse, M.C. Kruger, J. Coad</td>
<td>Show preview</td>
</tr>
<tr>
<td>64</td>
<td>The effect of dietary calcium on 1,25(OH)$_2$D$_3$ synthesis and sparing of serum 25(OH)D$_3$ levels</td>
<td>Paul H. Anderson, Alice M. Lee, Sarah M. Anderson, Rebecca K. Sawyer, Peter D. O’Loughlin, Howard A. Morris</td>
<td>Show preview</td>
</tr>
<tr>
<td>65</td>
<td>Vitamin D supplementation suppresses age-induced bone turnover in older women who are vitamin D deficient</td>
<td>Hilary F. Luderer, Marie B. Demay</td>
<td>Show preview</td>
</tr>
<tr>
<td>66</td>
<td>Worldwide status of vitamin D nutrition</td>
<td>P. Lips</td>
<td>Show preview</td>
</tr>
<tr>
<td>67</td>
<td>Despite mandatory fortification of staple foods, vitamin D intakes of Canadian children and adults are inadequate</td>
<td>Hassanali Vatanparast, Mona S. Calvo, Timothy J. Green, Susan J. Whiting</td>
<td>Show preview</td>
</tr>
<tr>
<td>68</td>
<td>Effects of a reduced nitrogen diet on calcitriol levels and calcium metabolism in growing goats</td>
<td>Alexandra Muscher, Korinna Huber</td>
<td>Show preview</td>
</tr>
<tr>
<td>69</td>
<td>Differential regulation of epidermal function by VDR coactivators</td>
<td>D.D. Bikle, A. Teichert, L.A. Arnold, Y. Uchida, P.M. Elias, Y. Oda</td>
<td>Show preview</td>
</tr>
<tr>
<td>70</td>
<td>The vitamin D receptor, the skin and stem cells</td>
<td>Hilary F. Luderer, Marie B. Demay</td>
<td>Show preview</td>
</tr>
<tr>
<td>71</td>
<td>The 1,25-dihydroxyvitamin D$_3$-independent actions of the vitamin D receptor in skin</td>
<td>Hilary F. Luderer, Marie B. Demay</td>
<td>Show preview</td>
</tr>
<tr>
<td>Page</td>
<td>Title</td>
<td>Author(s)</td>
<td>Type</td>
</tr>
<tr>
<td>------</td>
<td>----------------------------------------------------------------------</td>
<td>-----------------------------------------------</td>
<td>-----------------------</td>
</tr>
<tr>
<td>72</td>
<td>Conversion of vitamin D₃ to hormonally active 1α,25-dihydroxyvitamin D₃ in cultured keratinocytes: Relevance to cell growth and differentiation</td>
<td>Bodo Lehmann, Katrin Schättiger, Michael Meurer</td>
<td>Research Article</td>
</tr>
<tr>
<td>73</td>
<td>1,25-Dihydroxyvitamin D₃ modulates effects of ionizing radiation (IR) on human keratinocytes: In vitro analysis of cell viability/proliferation, DNA-damage and repair</td>
<td>Lea Trémezaygues, Markus Seifert, Thomas Vogt, Wolfgang Tilgen, Jörg Reichrath</td>
<td>Research Article</td>
</tr>
<tr>
<td>74</td>
<td>Holick’s rule and vitamin D from sunlight</td>
<td>John C. Dowdy, Robert M. Sayre, Michael F. Holick</td>
<td>Research Article</td>
</tr>
<tr>
<td>75</td>
<td>Variability of pre-vitamin D₃ effectiveness of UV appliances for skin tanning</td>
<td>Robert M. Sayre, John C. Dowdy, James G. Shepherd</td>
<td>Research Article</td>
</tr>
<tr>
<td></td>
<td>Vitamin D and cancer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>77</td>
<td>Epigenetic silencing of CYP24 in the tumor microenvironment</td>
<td>Candace S. Johnson, Ivy Chung, Donald L. Trump</td>
<td>Research Article</td>
</tr>
<tr>
<td>78</td>
<td>Vitamin D and breast cancer: Inhibition of estrogen synthesis and signaling</td>
<td>Anura V. Krishnan, Srilatha Swami, David Feldman</td>
<td>Research Article</td>
</tr>
<tr>
<td>79</td>
<td>Epidemiology of vitamin D and colorectal cancer: Casual or causal link?</td>
<td>Edward Giovannucci</td>
<td>Review Article</td>
</tr>
<tr>
<td>80</td>
<td>The effects of 1,25-dihydroxyvitamin D₃ on colon cancer cells depend on RhoA-ROCK-p38MAPK-MSK signaling</td>
<td>Paloma Ordóñez-Morán, Silvia Álvarez-Díaz, Noelia Valle, Maria Jesús Lamba, Félix Bonilla, Alberto Muñoz</td>
<td>Research Article</td>
</tr>
<tr>
<td>81</td>
<td>Genomic vitamin D signaling in breast cancer: Insights from animal models and human cells</td>
<td>Donald Matthews, Erika LaPorta, Glendon M. Zinser, Carmen J. Narvaez, JoEllen Welsh</td>
<td>Research Article</td>
</tr>
<tr>
<td>82</td>
<td>Tumor progression in the LPB-Tag transgenic model of prostate cancer is altered by vitamin D receptor and serum testosterone status</td>
<td>Sarah Mordan-McCombs, Theodore Brown, Wei-Lin Winnie Wang, Ann-Christin Gaupel, JoEllen Welsh, Martin Tenniswood</td>
<td>Research Article</td>
</tr>
<tr>
<td>83</td>
<td>Glucocorticoid regulation of the vitamin D receptor</td>
<td>Alejandro A. Hidalgo, Donald L. Trump, Candace S. Johnson</td>
<td>Research Article</td>
</tr>
<tr>
<td>84</td>
<td>Expression of the vitamin D receptor, 25-hydroxylases, 1α-hydroxylase and 24-hydroxylase in the human kidney and renal clear cell cancer</td>
<td>Martin Blomberg Jensen, Claus Bagelund Andersen, John E. Nielsen, Per Bagi, Anne Jørgensen, Anders Juul, Henrik Leffers</td>
<td>Research Article</td>
</tr>
<tr>
<td>Page</td>
<td>Title</td>
<td>Type</td>
<td>Pages</td>
</tr>
<tr>
<td>------</td>
<td>----------------------------------------------------------------------</td>
<td>-----------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>99</td>
<td>The role of cubilin gene polymorphisms and their influence on 25(OH)D₃ and 1,25(OH)₂D₃ plasma levels in type 1 diabetes patients</td>
<td>Original Research Article</td>
<td>442-444</td>
</tr>
<tr>
<td>100</td>
<td>1,25-Dihydroxyvitamin D₃ reduces systolic blood pressure in hypertensive adults: A pilot feasibility study</td>
<td>Original Research Article</td>
<td>445-447</td>
</tr>
</tbody>
</table>

Next ▶
Preface

Fourteenth Workshop on Vitamin D

The Fourteenth Workshop on Vitamin D was held at the Concertgebouw in Brugge, Belgium, from Sunday evening October 4 through October 8, 2009. A total of 420 registered delegates from 35 countries were in attendance.

The primary function of the Vitamin D Workshop is to organize and present scientific meetings on any aspect related to vitamin D. The first Vitamin D workshop meeting was held in Frankfurt, Germany in 1973 and they have been held at approximately 3-year intervals ever since, alternating between venues in the USA and Europe.

<table>
<thead>
<tr>
<th>Workshop number</th>
<th>Date</th>
<th>Number of delegates</th>
<th>Number of countries represented</th>
<th>Number of presentations</th>
<th>Presentations per delegate</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>October 1973</td>
<td>56</td>
<td>3</td>
<td>5</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>Frankfurt, West Germany</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>October 1974</td>
<td>221</td>
<td>22</td>
<td>84</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>Wiesbaden, West Germany</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III</td>
<td>January 1977</td>
<td>332</td>
<td>20</td>
<td>45</td>
<td>0.51</td>
</tr>
<tr>
<td></td>
<td>Asilomar, California, USA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>February 1979</td>
<td>402</td>
<td>26</td>
<td>80</td>
<td>0.76</td>
</tr>
<tr>
<td></td>
<td>Berlin, West Germany</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>V</td>
<td>February 1982</td>
<td>455</td>
<td>25</td>
<td>95</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>Williamsburg, Virginia, USA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>March 1985</td>
<td>474</td>
<td>27</td>
<td>77</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>Merano, Italy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>April 1988</td>
<td>381</td>
<td>24</td>
<td>82</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>Rancho Mirage, California, USA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VIII</td>
<td>July 1991</td>
<td>595</td>
<td>32</td>
<td>76</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>Paris, France</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IX</td>
<td>May 1994</td>
<td>502</td>
<td>31</td>
<td>91</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>Orlando, Florida, USA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X</td>
<td>May 1997</td>
<td>571</td>
<td>37</td>
<td>87</td>
<td>0.78</td>
</tr>
<tr>
<td></td>
<td>Strasbourg, France</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XI</td>
<td>May 2000</td>
<td>376</td>
<td>30</td>
<td>83</td>
<td>0.86</td>
</tr>
<tr>
<td></td>
<td>Nashville, Tennessee, USA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XII</td>
<td>July 2003</td>
<td>323</td>
<td>30</td>
<td>75</td>
<td>1.03</td>
</tr>
<tr>
<td></td>
<td>Maastricht, The Netherlans</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XIII</td>
<td>April 2006</td>
<td>332</td>
<td>24</td>
<td>76</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>Victoria, BC, Canada</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>XIV</td>
<td>October 2009</td>
<td>420</td>
<td>35</td>
<td>61</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>Brugge, Belgium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The substantial attendance at the Brugge Workshop reflected the continuing world-wide interest in research developments related to vitamin D. Presented in a table above are the dates, attendance, and the number of talks given at the fourteen Vitamin D Workshops that have now been held.

This special volume of the *Journal of Steroid Biochemistry and Molecular Biology* represents the official published Proceedings of the Fourteenth Workshop on Vitamin D. The table of contents identifies the major topical sections of the Proceedings; the 107 chapters are listed under their appropriate topic heading. Within each topic, the first series of chapters are written by Plenary or Invited Speakers followed by the Free Communications. This Proceedings publication is the fourteenth in our Vitamin D Workshop series. The first eleven were published as independent stand alone books, each of approximately 1000 pages. For the Proceedings of the Twelfth Workshop on Vitamin D, the Workshop Advisory Committee decided to publish the Proceedings in a peer reviewed journal, the *Journal of Steroid Biochemistry and Molecular Biology*. We are delighted that the current editor, Dr. Jerzy Adamski, and Elsevier Press have extended to the Vitamin D Workshop the opportunity to again publish the Proceedings of the 14th Workshop in JSBMB.

The Scientific Program for the Fourteenth Workshop on Vitamin D was proposed by the Program Committee and implemented
by the Workshop Advisory Committee; membership of these two groups is listed on subsequent pages. The Program Committee members nominated scientists for consideration by the Advisory Committee as Invited Speakers. The objective here was to allow presentation of all viewpoints on all scientific topics related to vitamin D. Further, the Program Committee members collectively reviewed and scored the 252 submitted Free Communication abstracts, which were candidates for presentations. The scores were rank-ordered to allow selection of the top 20 abstracts for 10 min oral presentations at the Workshop.

The quality and diversity of the science presented at the Fourteenth Workshop on Vitamin D was again at a very high level. Remarkable progress continues to be made in the many research areas related to vitamin D. Over the first 11 Workshops (1973–2000) there were two primary foci of research presentations. (a) The traditional biological functions of vitamin D and 1α,25(OH)2-vitamin D3 in the general area of calcium homeostasis with important biological effects in the intestine, kidney and its related disease of renal osteodystrophy and bone and its disease state of osteoporosis. (b) The chemical synthesis by highly talented chemists of many hundreds of analogs of vitamin D’s steroid hormone, 1α,25(OH)2D3. The availability of these analogs permitted the elucidation of their specific biological properties and, at the molecular level of how 1α,25(OH)2D3 or its analogs bind to the vitamin D receptor, VDR, to produce both genomic responses as well as rapid responses (e.g. opening of calcium or chloride channels). The capstone of this era was the publication by Professor Dino Moras1 and his colleagues in 2000 of the X-ray structure of the VDR with a 1α,25(OH)2D3 ligand.

Since 2000, the research world of vitamin D has been transformed by two events. The first is the significant expansion of the vitamin D endocrine system as evidenced by the number of annual publications of peer-reviewed papers with the term ‘vitamin D’ in either the title or abstract that has increased from 600 to 700 (1990–1999) to 2200 papers in 2009. Secondly, the recognition of the presence of the VDR in at least 37 tissues and cell types and (1990–1999) to 2200 papers in 2009. Secondly, the recognition of the presence of the VDR in at least 37 tissues and cell types and

FOURTEENTH WORKSHOP ON VITAMIN D AWARDS
Young Investigator Award Recipients
Femke Baeke, K.U.Leuven, Belgium
Katie M. Dixon, University of Sydney, Australia
Maria J. Larribe, Universidad Autónoma de Madrid, Spain
Danisa Menegaz, University of California, Riverside, USA
Mark B. Meyer, University of Wisconsin-Madison, USA
Pamela von Hurst, Massey University, New Zealand
Yun Wang, Georgia Tech, USA
Kari Wong, University of Chicago, USA

Career Award Recipients
Daniel D. Bikle, VAMC, University of California, San Francisco, USA
Roger Bouillon1, K.U-Leuven, Belgium
Martin J. Calverley, Leo Pharma Co, Denmark
Sylvia S. Christakos, New Jersey Medical School, USA
Pierre J. De Clercq, Ghent University, Belgium
David D. Feldman, Stanford University School of Medicine, USA
Mark R. Haussler, University of Arizona, USA
Helen L. Henry, University of California, Riverside, USA
Michael F. Holick, University of Tennessee Health Science Center, USA
Noboru Kubodera, Chugai Pharmaceutical Co. Ltd., Japan
Rebecca S. Mason, University of Sydney, Australia
Dino Moras, Institut de Génétique et de Biologie Moléculaire et Cellulaire, France
Antonio Mouriño, Universidad de Santiago, Spain
Anthony W. Norman(b), University of California, Riverside, USA
(a) Co-organizer of 7 Vitamin D Workshops from 1981 to 2009.
(b) Co-organizer of 14 Vitamin D Workshops from 1973 to 2009.

Organizers
Fourteenth Workshop on Vitamin D

ADVISORY COMMITTEE
Roger Bouillon (Leuven, Belgium)
Anthony W. Norman (Riverside, CA, USA)

PROGRAM COMMITTEE
Daniel D. Bikle
Ricardo Boland
Sylvia Christakos
Pierre De Clercq
Marie Demay
David Feldman
Mark Haussler
Bruce Hollis
Candace Johnson
Shigeaki Kato
H. Phillip Koeffler
Noboru Kubodera
Christel Lamberg-Allardt
Yan Chun Li
Paul Macdonald
Rebecca Mason
Chantal Mathieu
John McGrath
Antonio Mouriño
John Pettifor
J. Wesley Pike
Gary Posner
Joerg Reichrath
Eduardo Slatopolsky
George Studzinski
Tatsuo Suda
Hans Van Leeuwen
Jolleen Welsh
John White
Susan Whiting

Official Sponsors and Donors
FOURTEENTH WORKSHOP ON VITAMIN D

Leadership Sponsors
Abbott Laboratories, USA
Chugai Pharmaceutical Co. Ltd., Japan
Merck Sharp & Dome by, Belgium

Sponsors
TEJIN Pharma Limited, Japan
DiaSorin S.p.A., Italy
FWO, Belgium

Donors
Cerbios-Pharma SA, Switzerland
Chromsystems Instruments and Chemicals, Germany
DSM Nutritional Products Ltd, Switzerland
Hybrigenics, France
IDS Ltd, United Kingdom
Institut de Recherches Internationales Servier, France
Nycomed, Belgium
Oy Verman Ab, Finland

Anthony W. Norman∗
Roger Bouillon
Jerzy Adamski
Department of Biochemistry and Division of Biomedical Sciences, University of California, 5456 Boyce Hall, Riverside, CA 92521, United States

* Corresponding author. Tel.: +1 951 827 4777; fax: +1 951 827 4784.
E-mail address: anthony.norman@ucr.edu
(A.W. Norman)
Search Results: Displaying 1-1 of 1 results
ISSN: 0960-0760

Journal of Steroid Biochemistry and Molecular Biology, The
Pergamon United Kingdom 0960-0760 1969 Active EUR 5314.0

Add Selected Items to Your Lists:
Add: (select an option) To: (select a list) + ADD

Copyright © 2010 ProQuest LLC | Privacy Policy | Terms of Use | Contact Us