

REVIEW

Overview on denominated allergens

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Introduction

Type I allergy is a heightened or altered reactivity of the immune system in response to external substances involving immunoglobulins of the IgE class. More than 15% of the population in industrial countries suffer from immediate-type allergic symptoms [1]. In recent years, allergy research into the immunological, biochemical and structural characterization of allergens has led to an enormous progress affecting diagnostics and therapeutics. This article summarizes important aspects of allergy research work on purified allergens. Characterized and denominated allergens have been listed. These data include biochemical and structural allergen characteristics as well as research results on human histocompatibility leucocyte antigens (HLA) restriction of the immune response, T- and B-cell epitopes and recombinant allergen expression. Allergens were isolated from a variety of different species. The taxonomy and relationship of different vertebrate, invertebrate as well as plant species from which allergens are isolated are also shown.

Denomination of allergens

If an allergen fulfils the purity criteria according to IUIS/WHO [2] it should be named according to the published suggestions. As a rule, the first three letters of the genus are followed by the first letter of the species and the allergen number [3]. Numbers should be assigned in the order of their identification using the same number for homologous proteins of related species. Difficulties arise when the protein is described by different groups at the same time or when homologies are not clear. For example, the egg allergen name Gal d 1 has been used for ovomucoid as well as for ovalbumin. Furthermore, Lol p 11 and Phl p 11 should not have the same number because they are not homologous; Lol p 11 is a trypsin inhibitor whereas Phl p 11 belongs to the profilin group. In addition, problems arise when multiple allergens are described and named before nomenclature suggestions have been published.

Most major allergens known today are proteins with molecular sizes from 3 to 80 kDa (see Tables 1–8), but no common structural, functional or chemical feature of these molecules that could explain their ability to elicit an IgE response has been found. It has been suggested that enzymatic or other biological activity may enhance the induction of an allergic response [4]. Since the biological function is only known for $\approx 44\%$ of characterized allergens (see Tables 1–8), a final decision is not possible. Approximately half of the known allergen functions are enzymatic activities, predominantly of the catabolic pathway. Solubility, amount and distribution of these enzymes in the cell (not restricted to compartments) may enhance the possibility to come into contact with them and therefore increase the risk of sensitization. Proteases for instance destroy epithelial surface layers. Thus, an increase in their uptake and contact with the immune system is the result.

Exposure

Everyday life is associated with exposure to an enormous number of potential allergens in the environment. Those from pollen, mites and pets belong to the most important ones. An important exposure site is the workplace. Especially in this field, the investigation of dose–response relations is crucial. Knowledge on threshold values could be a prerequisite for effective prevention measures.

Dose–response relationships and thresholds were determined for several antigens (e.g. from pigeons and mites [5]). Antibody levels correlate with frequency and intensity of contact with antigens such as those from latex, *Chironomidae* and house dust mite [6].

Allergen identification and characterization (molecular weight, amino acid sequence, structural data)

Extracts of allergen sources generally contain a high number of components. Only a small fraction of them, named allergens, bind detectable amounts of IgE from sera of ‘the average allergic individual’ (obtained from a serum pool). A generally accepted definition of a major allergen is IgE binding from $\geq 50\%$ of sera from a panel of exposed and sensitized individuals.

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Allergens from vertebrates												
									Investigations into:			
Allergen Designation	Originating species	Source of allergenic material	Biological allergen function	Exposure	Molecular weight (kD)	Amino-acid sequence	Structural data	Cross-reactivity with	Allergy associated with HLA-allele	B-cell-epitopes	T-cell-epitopes	Recombinant production
Gad c 1	<i>Gadus callarias</i>	fish (cod group)	parvalbumin	food	12	C	glycoprotein	---	---	with MoAb, IgE	---	---
			[27]		[27]	[28]	[27]			[27,29]		
Equ c 1	<i>Equus caballus</i>	horse hair	---	animal keeper, house dust	19-20	---		---	---	---	---	---
		[30]		[31]	[30,32,33]							
Equ c 2			---		51		heterodimer glycoprotein	---	---	---	---	---
					[32,33]		[34]					
Equ c 3			---		31		glycoprotein	---	---	---	---	---
					[32,33]		[34]					
Bos d 1	<i>Bos domesticus</i>	bovine hair	---	farmer, veterinarians	25	---		---	---	---	---	---
				[33]	[33,35]							
Bos d 2			---		22	---		---	---	---	---	---
					[33,35]							
Bos d 3			---		22	---	glycoprotein	---	---	---	---	---
					[33,35]		[33]					
Fel d 1	<i>Felis domesticus</i>	cat hair, saliva	---	animal keeper, house dust	monomer A=5 monomer B=13	C	heterotetramer monomers A a. B S-S-linked B=glycoprotein	---	yes	with MoAb, IgE	yes	yes
				[36,37]	[38]	[39]	[40]		[41]	[40,42,43]	[44-46]	[45]
Can f 1	<i>Canis familiaris</i>	dog hair, skin, saliva	---	animal keeper, house dust	22 - 25	C	---	---	---	with IgE	---	---
		[47,48]		[36,37,47]	[49,50]	[2]				[49]		
Can f 2			---	---	19 - 22	---	---	---	---	---	---	---
					[48]							
Can f 3		albumin	---	---	69	C	---	cats albumin	---	---	---	yes
			[51]		[48]	[51]		[51,52]				[51]
Mus m 1	<i>Mus musculus</i>	mouse urine, hair follicle, serum	prealbumin	animal keeper, laboratory	17 - 21		---	---	---	---	---	---
		[53,54]	[55]	[56]	[53,57]							
Rat n 1	<i>Rattus norvegicus</i>	rat urine, kidney, saliva, hide	prealbumin	animal keeper, laboratory	21		---	Rat n 1 with Rat n 2	---	---	---	---
		[54,60,61]	[58]	[59]	[60]							
Rat n 2			α 2-eu-globulin	---	16	C	---		---	---	---	---
			[58]		[60]	[62]		[58]				
Cav p 1	<i>Cavia porcellus</i>	guinea-pig dander, urine, hide, saliva	prealbumin	animal keeper, laboratory	10-25	---	---	---	---	---	---	---
		[63]	[54]		[54]							
Ory c 1	<i>Oryctolagus cuniculus</i>	rabbit saliva	---	animal keeper, laboratory	17		---	---	---	---	---	---
		[64]			[64]							
Gal d 1	<i>Gallus domesticus</i>	hen's egg	ovomucoid	food	28	C	---	---	---	---	---	---
			[65]		[2]	[2]						
Gal d 2		ovalbumin			44	C	X-ray	---	---	with MoAb, IgE	yes	---
		[65]			[2]	[66]	[11]			[67,68]	[69]	
Gal d 3		conalbumin			78	C	---	---	---	---	---	---
		[70]			[70]	[70]						
Gal d 4		lysozym			14	C	X-ray	---	---	with MoAb	---	---
		[65]			[2]	[2]	[10]			[10]		

Table 1.

Allergens from invertebrates												
Allergen Designation	Originating species	Source of allergenic material	Biological allergen function	Exposure	Molecular weight (kD)	Amino acid sequence	Structural data	Cross-reactivity with	Investigations into:			
									Allergy associated with HLA-allele	B-cell epitopes	T-cell epitopes	Recombinant production
Chi t 1-9	<i>Chironomus thummi</i>	Chironomidae larva, fish food	haemoglobin binding of O ₂	fish breeder	dimer 32 monomers 16	C	X-ray of Chi t 1.01, peptides with NMR	with haemoglobins of other chironomids	yes	with MoAb, IgE	yes	peptides (1-19, 61-80)
		[23]	[23]	[23]	[23,71]	[71]	[7]	[72]	[23]	[73]	[74]	[23]
Bom p 1	<i>Bombus pennsylvanicus</i>	bumble-bee venom	phospholipase	everybody in case of a sting	16	P	---	---	---	---	---	---
			[3]		[3]	[3]	---	---	---	---	---	---
Bom p 4			protease		---	P	---	---	---	---	---	---
			[3]			[3]						
Api m 1	<i>Apis mellifera</i>	bee venom	phospholipase A2 (PLA-2)	bee breeder	16	C	X-ray	wasp venom; <i>Trichoptera</i> ; <i>Compositae</i>	yes	with PoAb, MoAb	yes	yes
			[3]		[76]	[76]	[77]		[78]	[22]	[79,80]	[81]
Api m 2			hyaluronidase		41	C	---			---	---	yes
			[82]		[82]	[82]						[82]
Api m 4 (=3)			melittin, lytic toxin		2,8	C	X-ray of the tetramers NMR of monomer	African and European bee	yes	with MoAb	yes	cecropin melittin-hybrid
			[16]		[16]	[83]	[13]	[84]	[78]	[23,85,86]	[16]	[87]
Ves f 5	<i>Vespula flavopilosa</i>	yellow jackets venom	---	everybody in case of a sting	23	C	4 S-S bonds	---	---	---	---	---
					[88]	[88]	[88]					
Ves g 5	<i>Vespula germanica</i>	eastern yellow jackets venom	---		23	C	4 S-S bonds	---	---	---	---	---
					[88]	[88]	[88]					
Ves m 1	<i>Vespula maculifrons</i>	yellow jackets venom	phospholipase A1		34	C	---	---	---	---	---	---
			[89]		[89]	[89]						
Ves m 2			hyaluronidase		44	P	---	---	---	---	---	---
			[3]		[3]	[3]						
Ves m 5			---		23	C	4 S-S bonds	---	---	---	---	---
					[90]	[90]	[90]					
Ves p 5	<i>Vespula pennsylvanica</i>	western yellow jackets venom	---		23	C	4 S-S bonds	---	---	---	---	---
					[88]	[88]	[88]					
Ves s 5	<i>Vespula squamosa</i>	southern yellow jackets venom	---		23	C	4 S-S bonds	---	---	---	---	---
					[88]	[88]	[88]					
Ves vi 5	<i>Vespula vidua</i>	yellow jackets venom	---		23	C	4 S-S bonds	---	---	---	---	---
					[88]	[88]	[88]					
Ves v 1	<i>Vespula vulgaris</i>	yellow jackets venom	phospholipase A1		35	C	---	---	---	---	---	---
			[3]		[3]	[3]						
Ves v 2			hyaluronidase		44	P	---	---	---	---	---	---
			[3]		[3]	[3]						
Ves v 5			---		23	C	4 S-S bonds	---	---	---	---	---
					[90]	[88,90]	[90]					
Vesp c 1	<i>Vespa crabo</i>	European hornet venom	phospholipase		34	P	---	---	---	---	---	---
			[3]		[3]	[3]						
Vesp c 5			---		23	C	4 S-S bonds	---	---	---	---	---
					[88]	[88]	[88]					

Table 2.

Allergens from invertebrates												
Allergen Designation	Originating species	Source of allergenic material	Biological allergen function	Exposure	Molecular weight (kD)	Aminoacid sequence	Structural data	Cross-reactivity with	Investigations into:			
									Allergy associated with HLA-allele	B-cell epitopes	T-cell epitopes	Recombinant production
Pol a 5	<i>Polistes annularis</i>	paper wasp venom	---	everybody in case of a sting	23 [90]	C [90]	4 S-S bonds [90]	hornet, yellow jacket [90]	---	---	---	---
Pol e 5	<i>Polistes exclamans</i>	paper wasp venom	---		23 [90]	C [90]	4 S-S bonds [90]	---	---	---	---	---
Pol f 5	<i>Polistes fuscatus</i>	paper wasp venom	---		23 [88]	C [88]	4 S-S bonds [88]	---	---	---	---	---
Pol m 5	<i>Polistes metricus</i>	paper wasp venom	---		23 [88]	P [88]	4 S-S bonds [88]	---	---	---	---	---
Dol m 1	<i>Dolichovespula maculata</i>	white-faced hornet	phospholipase A1 [89]		34 [89]	C [91]	---	paper wasp [90]	---	---	---	---
Dol m 2			hyaluronidase [3]		44 [3]	C [92]	---	Api m 2 [92]	---	---	---	---
Dol m 5			---		23 [93,94]	C [93,94]	4 S-S bonds [94]	---	---	---	---	yes [94]
Dol a 5	<i>Dolichovespula arenaria</i>	yellow hornet venom	---		23 [90]	C [90]	4 S-S bonds [90]	---	---	---	---	---
Myr p 1	<i>Myrmecia pilosula</i>	bulldog ant venom	---	Australia [95]	7 [95]	C [95]	---	---	---	with IgE [96]	---	yes [95]
Sol i 1	<i>Solenopsis invicta</i>	red fire ant venom	phospholipase [97]	southeast USA [98]	37 [97]	P [97]	---	Ves m 1 [97]	---	---	---	---
Sol i 2			---	tropic areas [97]	monomer 13 [98]	C [98,99]	homodimer S-S linked [98]	---	---	---	---	---
Sol i 3			---		24 [98]	C [98]	4 S-S bonds [98]	---	---	---	---	---
Sol i 4			---		13.3 [98]	C [98]	monomer [98]	---	---	---	---	---
Sol r 1	<i>Solenopsis richteri</i>	fire ant venom [97]	---	USA [97]	---	P [97]	---	Sol i 1 [97]	---	---	---	---
Sol r 2			---		---	C [97]	---	Sol i 2 [97]	---	---	---	---
Sol r 3			---		---	C [97]	---	Sol i 3 [97]	---	---	---	---
Bla g 1	<i>Blattella germanica</i>	cockroach, house dust [100]	---	everybody, pre dominantly USA [100]	20-25 [101]	---	---	---	---	---	---	---
Bla g 2			aspartic protease [101]		36 [100,102]	P [102]	---	<i>Periplaneta</i> [102]	---	---	---	---
Bla g 4			calycin [101]		21 [101]	C [101]	modelling [101]	---	---	---	---	---
Bla g 5			glutathione transferase [101]		25 [101]	C [101]	---	---	---	---	---	---
Bla g 6			troponin [101]		25 [101]	C [101]	---	---	---	---	---	---
Per a 1	<i>Periplaneta americana</i>	cockroach, house dust [100]	---	pre-dominantly USA [100]	20-25 [101]	---	---	<i>Blattella</i> [102]	---	---	---	---
Per a 3			---		72-78 [101]	---	---	---	---	---	---	---

Table 3.

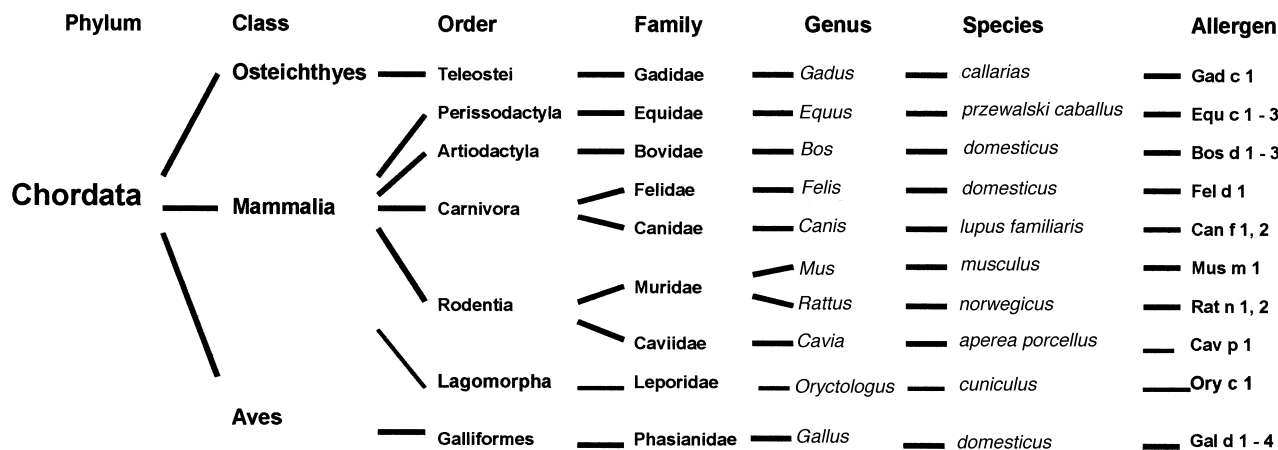


Fig. 1. Taxonomy of vertebrates.

Electrophoretic separation according to molecular weight sodium dodecyl sulfate-polyacrylamide gel electrophoresis (SDS-PAGE) and isoelectric point or isoelectric focusing (IEF) or, combining both methods, by two-dimensional electrophoresis should be performed to characterize single proteins. A successful method to recognize allergens in an extract is the immunoblot. After electrophoresis, the material is transferred to immobilizing membranes and incubated with sera of sensitized patients. Allergens are detected with anti-human-IgE antibodies labelled radioactively or enzymatically. For purification of allergens size-exclusion-, ion-exchange- or affinity chromatography are used. After purification of the allergen, only one band or spot should be detectable with gel electrophoresis. The N-terminal or total sequencing of the protein offers the possibility to compare them with known proteins in databases.

Both degrading and denaturing of the allergen molecule in allergen extracts must be avoided in order to conserve the three-dimensional structure and thus the IgE-binding epitopes. Antigen-antibody reaction is mainly influenced by three-dimensional structures known to apply to the allergens

Chi t 1.01 [7], Amb a 5 and Amb t 5 [8,9], Gal d 2 and 4 [10,11], Asp o 2 [12] and Melittin (Api m 4) [13]. Structure determination is performed by nuclear magnetic resonance spectroscopy (NMR) and X-ray analysis. The latter needs the protein to be crystallized whereas NMR allows analysis of the substance in liquid state. NMR measures the amount of amino acids as well as the neighbourhood of protons of different amino acid residues. The alternating effect of two protons along the carbon backbone is characteristic of structural motives. A precise identification and careful selection of raw allergen sources and raw materials are basic criteria to obtain standardized allergen extracts for clinical diagnosis.

Crossreactivity

Study of crossreactivity among allergens, i.e. binding to immunoglobulin molecules (IgE) of the same specificity, is of significance both for clinical and basic research. Cross-reactivity of allergens occurs if different proteins are more or less homologous and contain identical or nearly identical epitopes. Frequently, it can be classified and explained on

Tables 1–8. The tables show a variety of relevant data on each allergen.

‘Exposure’ provides information on the most frequently exposed individuals and sensitizers. In case of pollen allergens, blossom periods (European climate) are included.

Structural data include disulphide bonds and glycosylation. If the structure of the whole molecule is known, the method (X-ray or NMR) is mentioned. The method is registered for mapping B-cell epitopes (monoclonal antibodies [MoAbs], polyclonal antibodies [PoAbs], human IgE sera [IgE]). The order of allergens is according to their taxonomy (Figs 1–3).

Molecular weights of isoforms are expressed as 29/30 for example.

It should be noted that the definition of allergen molecules is not necessarily straightforward and that some controversies still exist.

P = partial

C = complete

— — — = information not yet available to the authors.

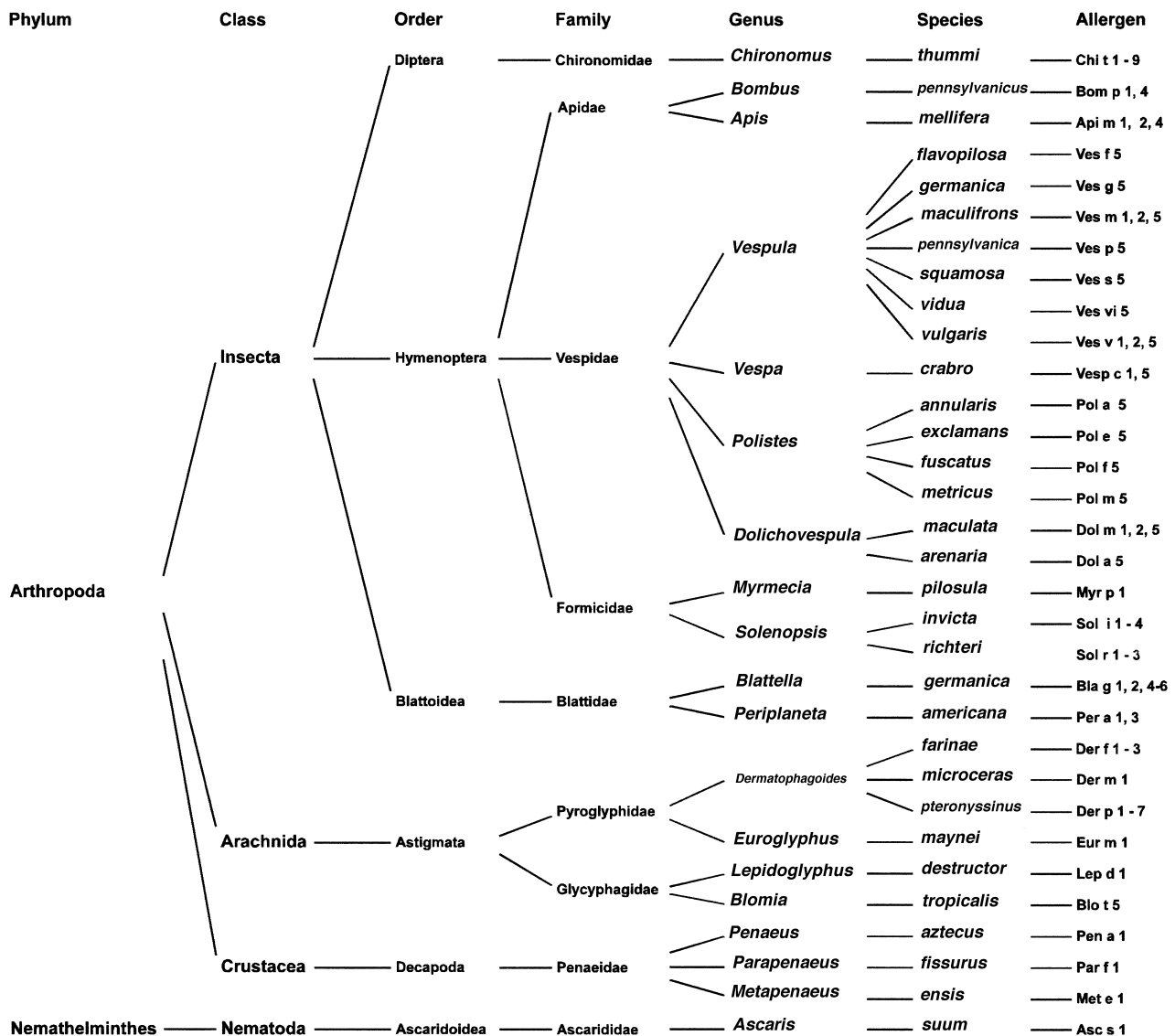


Fig. 2. Taxonomy of invertebrates.

the basis of taxonomic relationships (Figs 1–3) because closely related organisms often have great similarities and share a number of antigens, e.g. pollen from different species of the same genus/family [14]. It should be noted that other crossreactions are caused by evolutionary conserved protein structures. Profilin, a conserved protein in eukaryotic cells, is responsible for most of the crossreactivity between birch pollen (birch profilin = Bet v 2) and extracts of vegetables such as carrots and potatoes [15]. A third type of crossreactivity responsible for crossreactions between even less phylogenetically related glycoproteins is due to the carbohydrate chains of these allergens [16].

The consequence of a strong crossreactivity is the sensitization to allergens without exposure.

For the determination of crossreactivity, murine monoclonal antibodies as well as human IgE sera can be used. Many approaches to identify crossreactive allergens have been made, e.g. crossed immunoelectrophoresis, immunoblotting, radioallergosorbent test (RAST) inhibition, and desoxyribonucleic acid/ribonucleic acid (DNA/RNA) hybridization [14,17]. It should be mentioned that not all of the crossreactivities detected by these methods are of clinical relevance.

Association of allergen-specific immune response with HLA-alleles

The recognition of allergen requires the T cell with the T-cell

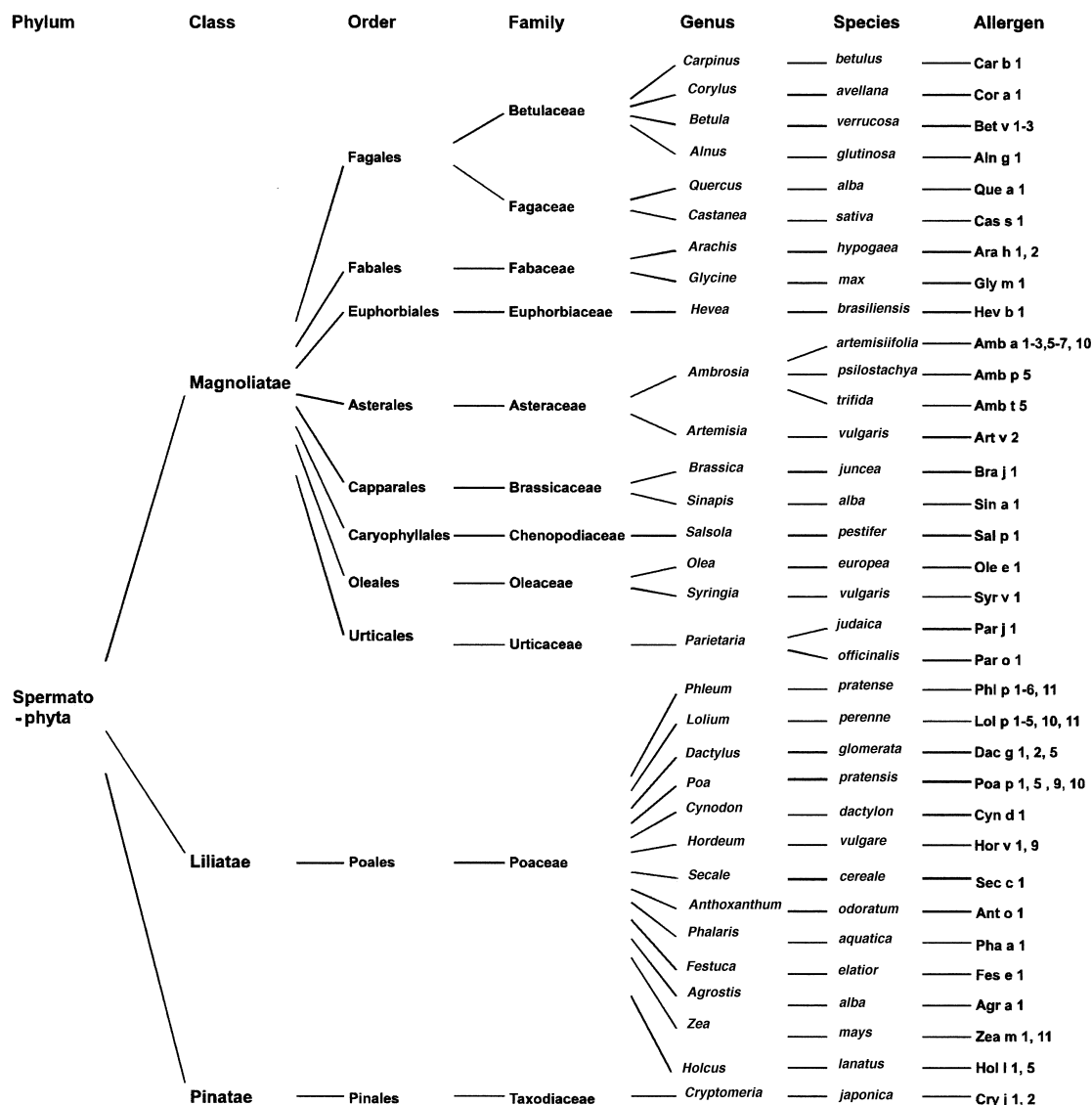


Fig. 3. Taxonomy of plants.

receptor as well as an antigen-presenting cell with major histocompatibility complex (MHC) class II proteins (encoded in the HLA-D region of the human genome). A genetic predisposition frequently seems to play a role in allergen recognition. Every individual is characterized by a specific HLA-type, and therefore special possibilities of epitope binding exists. The HLA-type can be evaluated using sequence-specific oligonucleotides and the polymerase chain reaction (PCR). DNA is isolated from small amounts of lymphocytes and used as template for PCR. HLA associations with sensitization to several characterized allergens have been described [18].

Other genetic aspects may be of relevance for allergic diseases as well. A linkage of mutations on the 5q [19]

and 11q [20] genes with total IgE has been found and is controversially discussed at present. T-cell receptor (TCR) genes are likely to play a role in the susceptibility to the IgE response.

B-cell and T-cell epitopes

Most important for the evaluation of new diagnostic and therapeutic approaches, the knowledge of allergic reactions and the understanding of fundamental immunological features is the determination of epitopes. In the past, research mainly focused on the detection of immunoglobulin-binding regions (B-cell epitopes). Recently,

Allergens from invertebrates												
Allergen Designation	Originating species	Source of allergenic material	Biological allergen function	Exposure	Molecular weight (kD)	Aminoacid sequence	Structural data	Cross-reactivity with	Investigations into:			
									Allergy associated with HLA-allele	B-cell epitopes	T-cell epitopes	Re-combinant production
Der f 1	<i>Dermato - phagoides farinae</i>	house dust [4]	cysteine protease [4]	everybody [103,104]	25 [2]	C [105]	---	---	---	with MoAb, IgE [106]	---	---
Der f 2			lysozym? [4]		14.1 [107]	C [107,108]	3 S-S bonds [109]	---	---	---	---	yes [108]
Der f 3			trypsin [110,111]		34 [110]	P [110]	---	---	---	---	---	---
Der f ?			tropomyosin [112]		39 [113]	C [112]	---	---	---	with IgE [114]	---	yes [112,113]
Der m 1	<i>Dermato - phagoides microceras</i>	house dust [115]	Cysteine protease	---	25 [2]	P [115]	---	other mites [116]	---	---	---	---
Der p 1	<i>Dermato - phagoides pteronyssinus</i>	Acarus excrement, house dust [4,117]	cysteine protease [118]	everybody [103,104]	25 [118]	C [118,119]	modelling [120]	other mites	yes [116,121,122]	MoAb, IgE [124,125]	yes [126]	yes [119]
Der p 2			lysozym? [4]		14.1 [127]	C [127]	---	---	---	IgE [128,129]	yes [130]	yes [127]
Der p 3			trypsin [111]		31 [111]	P [111]	---	Der p 1 [131]	---	---	---	yes [132]
Der p 4			amylase [133]		56-60 [133,134]	P [134]	---	---	---	---	---	---
Der p 5			---		14 - 17.5 [135,136]	C [135]	---	---	---	---	---	yes [135]
Der p 6			chymotrypsin [137]		25 [137]	P [137]	---	---	---	---	---	---
Der p 7			---		22-28 [4]	C [138]	glycoprotein [138]	---	---	---	---	yes [138]
Eur m 1	<i>Euroglyphus maynei</i>	house dust [139]	cysteine protease [139]	---	23.6 [139]	C [139]	glycoprotein [139]	Der p 1 Der f 1 [139]	---	---	---	---
Lep d 1	<i>Lepidoglyphus destructor</i>	food storage [140]	---	---	14-16 [141]	P [141]	---	---	---	---	---	---
Blo t 5	<i>Blomia tropicalis</i>	food storage [140]	---	tropical areas [104]	---	C [142]	---	---	---	---	---	yes [142]
Pen a 1	<i>Panagaeus aztecus</i>	brown shrimp body	tropomyosin [143,144]	food [144]	36 [144]	P [143]	---	mites, insects [145]	---	with IgE, MoAb [143,146]	---	---
Par f 1	<i>Parapanaeus fissurus</i>	shrimps	serum albumin [147]	food	39 [147]	P [147]	---	---	---	---	---	---
Met e 1	<i>Metapanaeus ensis</i>	shrimps	tropomyosin [148]	food	34 [148]	C [148]	---	---	---	---	---	yes [148]
Asc s 1	<i>Ascaris suum</i>	pig round worm	---	food	14 [149]	P [150]	---	---	---	---	---	---

Table 4.

the relevance of T-cell epitopes was revealed as well. The analysis of B-cell epitopes is performed with peptides of the allergen using human IgE sera, polyclonal rabbit sera or murine monoclonal antibodies. A disadvantage of this method is that only linear epitopes can be identified.

Antibody binding sites (B-cell epitopes) involve sequential as well as conformational epitopes [21]. Analyses have shown that B-cell epitopes are predominantly conformational, containing more or less dominating elements of sequential nature. For example, epitopes on

Allergens from plants												
Allergen Designation	Originating Species	Source of allergenic material	Biological allergen function	Exposure	Molecular weight (kD)	Amino acid sequence	Structural data	Cross-reactivity with	Investigations into:			
									Allergy associated with HLA-allele	B-cell epitopes	T-cell epitopes	Re-combinant production
Car b 1	<i>Carpinus betulus</i>	hornbeam pollen	---	pollen time IV - V	17 [151]	C [151]	---	<i>Fagales</i> group 1 [151,152]	---	---	---	yes [151]
Cor a 1	<i>Corylus avellana</i>	hazel pollen	---	pollen time II - IV	17.5 [153]	C [153]	---	<i>Fagales</i> -group 1 [154]	---	with IgE [155]	yes [156]	yes [153]
Bet v 1	<i>Betula verrucosa</i>	birch pollen	---	pollen time IV - V	17.4 [157]	C [157]	---	apples, hazelnuts, other No.1 allergens of <i>Fagales</i> [152,154]	yes [158,159]	with MoAb, IgE [15,155]	yes [156]	yes [160]
Bet v 2			profilin [161]	---	14.2 [161]	C [161]	---	plantprofilin [162,163]	---	---	---	yes [161]
Bet v 3			Ca ²⁺ binding protein [164]	---	---	C [164]	---	---	---	---	---	yes [164]
Aln g 1	<i>Alnus glutinosa</i>	alder pollen	---	pollen time III - IV	17 [165]	C [165]	---	<i>Fagales</i> group 1 [152,154]	---	---	---	yes [165]
Que a 1	<i>Quercus alba</i>	oak pollen	---	pollen time IV - VI	17 [152]	C [152]	---	<i>Fagales</i> group 1 [152]	---	---	---	---
Cas s 1	<i>Castanea sativa</i>	chestnut pollen	---	pollen time VI	22 [166]	P [166]	---	Bet v 1 [166]	---	---	---	---
Ara h 1	<i>Arachis hypogea</i>	peanut	---	food	63 [167]	C [167]	---	---	---	with IgE [167]	---	---
Ara h 2			---		17 [168]	P [168]	---	---	---	with IgE [168]	---	---
Gly m 1	<i>Glycine max</i>	soybean hulls [169]	---	dust	7 [169]	P [169]	glycoprotein [169]	---	---	---	---	---
Hev b 1	<i>Hevea brasiliensis</i>	latex	rubber elongation factor [170]	hospital worker, spina bifida patients	14 [171]	C [172]	---	---	---	---	---	---
Amb a 1	<i>Ambrosia artemisiifolia</i>	short ragweed pollen	---	USA, parts of Germany	38 [3]	C [173]	---	Amb a 2 [174]	---	with MoAb [175-177]	---	yes [173,174,177]
Amb a 2			---	pollen time VIII - X	38 [178]	C [174,178]	---	Amb a 1 [174]	---	---	yes [174]	yes [174,178]
Amb a 3			---		11.4 [179]	C [179]	glycoprotein [179]	---	---	yes [180]	yes [180]	---
Amb a 5			---		4.4 - 6 [181]	C [182,183]	NMR [8,184]	Amb t 5 [181]	yes [185]	---	---	yes [182,184]
Amb a 6			---		10 [3]	C [3]	---	---	yes [186]	---	---	---
Amb a 7			---		12 [3]	P [3]	---	---	---	---	---	---
Amb a ?			---		11 [3]	C [3]	---	---	---	---	---	---
Amb a 10			cytochrom c		---	---	---	---	---	---	---	---
Amb p 5	<i>Ambrosia psilostachya</i>	western ragweed	---	---	---	C [187]	---	Amb a 5 [188]	---	---	---	---
Amb t 5	<i>Ambrosia trifida</i>	giant ragweed	---	USA, pollen time VIII - X	4.3 [189]	C [189,190]	NMR [9]	Amb a 5 [181]	yes [189]	---	---	yes [184]
Art v 2	<i>Artemisia vulgaris</i>	mugwort	---	pollen time VII-X	19-20 [191]	P [191]	glycoprotein [192]	---	---	---	---	---

Table 5.

Allergens from plants												
Allergen Designation	Originating species	Source of allergenic material	Biological allergen function	Exposure	Molecular weight (kD)	Amino acid sequence	Structural data	Cross-reactivity with	Investigations into:			
									Allergy associated with HLA-allele	B-cell epitopes	T-cell epitopes	Re-combinant production
Bra j 1	<i>Brassica juncea</i>	oriental mustard seeds	2-S albumin [193]	food	14.6 [193]	C [193]	two chains SS-linked [193]	<i>Sinapis</i> [193]	---	with MoAb, IgE [193]	---	---
Sin a 1	<i>Sinapis alba</i>	yellow mustard seeds	2-S albumin [194]	food	14.2 [195]	C [194,195]	two chains SS-linked [194]	<i>Brassica</i> [193]	---	with MoAb, IgE [196]	---	yes [195]
Sal p 1	<i>Salsola pestifer</i>	pollen	---	pollen time VII - IX	---	---	---	---	---	---	---	---
Ole e 1	<i>Olea europea</i>	olive tree pollen	---	pollen time IV - VI	16-20 [197,198]	C [197,199]	glycoprotein [198]	other <i>Oleaceae</i> [200]	yes [201]	with MoAb [200]	---	yes [202]
Syr v 1	<i>Syringia vulgaris</i>	lilac pollen	---	---	16-20 [203]	C [203]	glycoprotein [203]	<i>Oleaceae</i> group 1 [203]	---	---	---	---
Par j 1	<i>Parietaria judaica</i>	pollen	---	---	10.5/13 [204]	C [205]	glycoprotein [206]	---	---	---	---	---
Par o 1	<i>Parietaria officinalis</i>	pollen	---	pollen time VI-IX	14 [207]	P [207]	---	---	---	---	---	---
Phl p 1	<i>Phleum pratense</i>	timothy grass pollen	---	pollen time VI - VIII	34 [208]	C [208,209]	---	grass allergens group 1 [210,211]	---	with MoAb [211]	---	yes [209,212]
Phl p 2			---		10-12 [213]	C [213]	---	grass allergens group 2	---	---	---	---
Phl p 3			---		10 - 12 [213]	C [213]	---	grass allergens group 3	---	---	---	---
Phl p 4			---		54 [214,215]	---	glycoprotein [215]	grass allergens group 4	---	---	---	---
Phl p 5			ribonuclease [216]		29,31 [217,218]	C [217,219]	---	grass allergens group 5 [220]	---	with MoAb [218,221]	---	yes [219]
Phl p 6			---		11 [210]	C [210]	---	grass allergens group 6	---	---	---	---
Phl p 11			profilin [222]		14.2 [222]	C [222]	---	---	---	---	---	---
Lol p 1	<i>Lolium perenne</i>	rye grass pollen	---	pollen time V - IX	28.4/31 [223,224]	C [223,225]	---	homology to Lol p 2 u. 3 [226]	yes [227]	with MoAb [211]	yes [228,229]	yes [230]
Lol p 2			---		10.9 [231]	C [231,232]	---	59% homology between [233]	yes [233]	---	yes [234]	yes [230,232]
Lol p 3			---		10.9 [226]	C [226]	---	Lol p 2 u. 3 [226]	yes [233,235]	---	yes [234]	---
Lol p 4			---		57 [236]	P [236]	---	---	---	with MoAb [237,238]	---	---
Lol p 5 = Lol p 9?			---		25/28 [239]	C [240,241]	---	grass allergens group 5 [220,242]	---	with MoAb, IgE [243]	---	yes [240]
Lol p 10			cytochrom c [244]		12 [245]	---	---	grass allergens group 10 [245]	---	---	---	---
Lol p 11			trypsin inhibitor [246]		18 [239]	C [246]	glycoprotein [246]	homology to Ole e 1 [246]	---	---	---	---

Table 6.

Allergens from plants												
Allergen Designation	Originating species	Source of allergenic material	Biological allergen function	Exposure	Molecular weight (kD)	Amino acid sequence	Structural data	Cross-reactivity with	Investigations into:			
									Allergy associated with HLA-allele	B-cell epitopes	T-cell epitopes	Re-combinant production
Dac g 1	<i>Dactylis glomerata</i>	cocksfoot pollen	---	pollen time V - VI	32 [247]	P [247]	---	Lol p 1 [248]	---	with MoAb [248]	---	---
Dac g 2			---		11 [249]	C [249]	---	---	---	---	---	yes [230,249]
Dac g 5			---		25/28 [241,250]	P [241,250]	---	---	---	---	---	---
Poa p 1	<i>Poa pratensis</i>	kentucky blue grass pollen	---	pollen time VII - VIII	33/36 [251]	P [252]	---	grass allergens group 1 [252]	---	with MoAb [253]	---	---
Poa p 5			---		26/28 [241]	P [241]	---	N-terminal homology between [241,255]	---	---	---	---
Poa p 9			---		29-35 [254]	C [254]	---	Poa p 5 u. 9 [241,255]	---	yes [256]	---	yes [255]
Poa p 10			cytochrom c [245]		29	---	---	Lol p 10 [245]	---	---	---	---
Cyn d 1	<i>Cynodon dactylon</i>	bermuda grass pollen	---	pollen time V - VI	29/32 [257]	P [257,258]	glycoprotein [257]	grass allergens group 1 [242,257]	---	---	---	yes [258]
Hor v 1	<i>Hordeum vulgare</i>	barley flour	α -amylase / trypsin inhibitor (BMAI-1) [259]	bakers	14.5 [259]	C [259]	glycoprotein [259]	---	---	---	---	---
Hor v 9		barley pollen	---	pollen time VI	30 [260]	C [260]	---	Poa p 9 Phl p 5 [260]	---	---	---	---
Sec c 1	<i>Secale cereale</i>	rye flour	α -amylase / trypsin inhibitor [261]	bakers	13.5 [261]	C [261]	dimer [261]	---	---	---	---	---
Ant o 1	<i>Anthoxanthum odoratum</i>	sweet vernal grass pollen	---	pollen time V - VIII	34 [252]	P [252]	---	grass allergens group 1	---	---	---	---
Pha a 1	<i>Phalaris aquatica</i>	canary grass pollen	---	pollen time V - X	34 [262]	P [262]	---	group 1 allergens [262]	---	---	---	---
Fes e 1	<i>Festuca elatior</i>	meadow fescue	---	pollen time VI - VII	34 [252]	P [252]	---	grass allergens group 1	---	---	---	---
Agr a 1	<i>Agrostis alba</i>	---	---	pollen time VI - VIII	---	P [252]	---	grass allergens group 1	---	---	---	---
Zea m 1	<i>Zea mays</i>	maize pollen	---	pollen time VII-IX	21.4 [263]	P [263]	---	Lol p 1 [263]	---	---	---	---
Zea m 11			profilin [264]		14 [264]	C [264]	---	---	---	---	---	---
Hol l 1	<i>Holcus lanatus</i>	velvet grass pollen	---	pollen time VI - VIII	34 [239]	C [265]	---	grass allergens group 1	---	---	---	---
Hol l 5			---		30 [239]	C [239]	---	---	---	---	---	---
Cry j 1	<i>Cryptomeria japonica</i>	cedar pollen	pectase lyase [266]	Japan	38.5 [267]	C [267]	glycoprotein [268]	<i>Cupressus sempervirens</i> [268]	yes [18]	with MoAb, IgE [265,268,269]	---	---
Cry j 2			poly-galacturonase [270]		37 [271]	C [270]	---	<i>Cupressus sempervirens</i> [268]	---	---	---	yes [270]

Table 7.

Allergens from plants												
Allergen Designation	Originating species	Source of allergenic material	Biological allergen function	Exposure	Molecular weight (kD)	Amino acid sequence	Structural data	Cross-reactivity with	Investigations into:			
									Allergy associated with HLA-allele	B-cell epitopes	T-cell epitopes	Recombinant production
Asp f 1	<i>Aspergillus fumigatus</i>	germinative fungus spores	restrictocin mitogillin, rRNAase	patients with cystic fibrosis	18	C	two S-S bonds	---	---	---	---	yes
			[272]	[273,274]	[272]	[272]	[272]					[275]
Asp o 2	<i>Aspergillus oryzae</i>	bread improver	α -amylase	bakers	53	C	X-ray	---	yes	---	---	yes
		[276]	[276]	[276]	[276]	[277,278]	[12]		[279]			[280]
Alt a 1	<i>Alternaria alternata</i>	mycelium, spores	---		28-31	P	glycoprotein	---	yes	---	---	---
		[281]		[282]	[281,282]	[3]	[281]		[41]			
Cand a 1	<i>Candida albicans</i>	---	alcohol-dehydrogenase	---	40	C	---	yeast	---	---	---	---
			[283]		[283]	[283]		[283]				
Tri t 1	<i>Trichophyton tonsurans</i>	---	exo-1,3-beta-glucanase	---	30	P	---	---	---	---	---	---
			[284]		[285]	[285]						
Cla h 1	<i>Cladosporium herbarum</i>	fungus spores	---	---	30	---	---	---	---	---	---	---
		[286]										
Cla h 2			---	---	54?	---	glycoprotein	---	---	---	---	---
					[286]		[286]					
Cla h 3			ribosomal P2 protein	---	11.1	C	---	---	---	---	---	yes
			[287]		[287]	[287]						[287]
Psi c 2	<i>Psilocybe cubensis</i>	---	cyclophilin	---	16	C	---	---	---	---	---	yes
			[261]		[261]	[261]						[261]

Table 8.

phospholipase A2 (Api m 1) have recently been shown to be predominantly discontinuous by peptide mapping with monoclonal and polyclonal antibodies [22]. However, only the analysis of antibody-antigen-complexes by X-ray clearly reveals the interacting parts of the molecule [10].

In addition, a central role of the T cell for the allergic reaction has been recognized.

T cells recognize predominantly linear allergen sequences in combination with MHC class II molecules. Determination of T-cell epitopes has been performed with peripheral blood lymphocytes or T-cell clones induced to proliferate by allergen peptides. There are differences dependent on the concentration of the allergen as well as on the blood donor. However, nearly each allergen-derived sequence of sufficient length may act as T-cell epitope [23]. Epitope recognition may lead to conformational changes of the T-cell receptor [24]. Subsequently, the induction of the TH₂-cytokine pattern triggers the allergic response. It should be noted that T cells produce a continuously changing spectrum of cytokine profiles in which the TH₂ cell is only one possible extreme phenotype [25].

Recombinant allergen production

Recombinant methods offer the opportunity to obtain well characterized allergens of high purity for clinical tests (e.g skin-prick test) or experimental studies to enhance the knowledge of allergic reactions. The aim is to standardize extracts and to perform diagnosis with small, clearly defined panels of purified allergens. Recombinant allergens and peptides are hoped to act as catalysts for the allergen-specific immunotherapy [26].

To reach recombinant proteins, one basically has to know the nucleotide sequence of the gene coding for the allergen of interest. A standard procedure is PCR to catch and amplify the gene from cDNA. After cloning and expression in a suitable vector/host system, a large amount of allergens of high purity can be extracted.

Summary—Conclusions

More than 160 proteins of 73 different species causing hypersensitivity type I reactions in humans are known and denominated. Origin and characteristics of these allergens show a great variety. No single 'allergen-feature' can be

described so far. Not only the allergen but also its interactions with MHC class II molecules, IgE immunoglobulins and T cells via T-cell receptors induce the immune response and finally clinical symptoms. Detailed knowledge of the molecules and their interactions is the prerequisite for new ways of prevention, diagnostics and therapy.

References

- Kay AB, Lessof MH. Allergy Conventional and alternative concepts. A report of the Royal College of Physicians Committee on Clinical Immunology and Allergy [Review]. *Clin Exp Allergy* 1992; 22 Suppl 3:1–44.
- Marsh DG, Goodfriend L, King TP, Lowenstein H, Platts-Mills TA. Allergen nomenclature. *Bulletin WHO* 1986; 64:767–74.
- King TP, Hoffman DR, Lowenstein H, Marsh DG, Platts-Mills TA, Thomas WR. Allergen nomenclature WHO/IUIS Allergen Nomenclature Subcommittee. *Int Arch Allergy Immunol* 1994; 105:224–33.
- Thomas WR. Mite allergens groups I–VII A catalogue of enzymes. *Clin Exp Allergy* 1993; 23:350–3.
- Baur X. New aspects of isocyanate asthma [Review]. *Lung* 1990; 168 Suppl:606–13.
- Liebers V, Hoernstein M, Baur X. Humoral immune response to the insect allergen Chi t I in aquarists and fish-food factory workers. *Allergy* 1993; 48:236–9.
- Steigemann W, Weber E. Structure of erythrocrurin in different ligand states refined at 1.4 Å resolution. *J Mol Biol* 1979; 127:309–38.
- Metzler WJ, Valentine K, Roebber M, Marsh DG, Mueller L. Proton resonance assignments and three-dimensional solution structure of the ragweed allergen Amb a V by nuclear magnetic resonance spectroscopy. *Biochemistry* 1992; 31:8697–705.
- Metzler WJ, Valentine K, Roebber M, Friedrichs MS, Marsh DG, Mueller L. Determination of the three-dimensional solution structure of ragweed allergen Amb t V by nuclear magnetic resonance spectroscopy. *Biochemistry* 1992; 31:5117–27.
- Amit AG, Mariuzza RA, Phillips SE, Poljak RJ. Three-dimensional structure of an antigen-antibody complex at 2.8 Å resolution. *Science* 1986; 233:747–53.
- Stein PE, Leslie AG, Finch JT, Turnell WG, McLaughlin PJ, Carrell RW. Crystal structure of ovalbumin as a model for the reactive centre of serpins. *Nature* 1990; 347:99–102.
- Swift HJ, Brady L, Derewenda ZS et al. Structure and molecular model refinement of *Aspergillus oryzae* (TAKA) alpha-amylase: an application of the simulated-annealing method. *Acta Cryst* 1991; 47:535–44.
- Terwillinger TC, Eisenberg D. The structure of melittin. II. Interpretation of the structure. *J Biol Chem* 1982; 257: 6016.
- Mohapatra SS. Structural motifs as a basis of cross-reactivity among pollen allergens. In: Kraft D, Sehon A eds. *Molecular Biology and Immunology of Allergens*. Boca Raton, Ann Arbor, London, Tokyo: CRC Press, 1993:69–81.
- Akkerdaas JH, van Ree R, Aalbers M, Stapel SO, Aalberse RC. Multiplicity of cross-reactive epitopes on Bet vI as detected with monoclonal antibodies and human IgE. *Allergy* 1995; 50:215–20.
- King TP, Coscia MR, Kochoumian L. Structure-immunogenicity relationship of a peptide allergen, melittin. In: Kraft D, Sehon A eds. *Molecular biology and immunology of allergens*. Boca Raton Ann Arbor London Tokyo: CRC Press, 1993:11–19.
- Baldo BA. Editorial: Allergenic crossreactivity of fungi with emphasis on yeast: Strategies for further study. *Clin Exp Allergy* 1995; 25:488–92.
- Rihs HP, Baur X. Genetische Untersuchung zur Prädisposition atopischer Erkrankungen. *Deutsches Ärzteblatt* 1994; B: 732–5.
- Marsh DG, Neely JD, Breazeale DR et al. Linkage analysis of IL4 and other chromosome 5q311 markers and total serum immunoglobulin E concentrations. *Science* 1994; 264: 1152–6.
- Sandford AJ, Shirakawa T, Moffatt MF et al. Localisation of atopy and beta subunit of high-affinity IgE receptor (Fc epsilon RI) on chromosome 11q. *Lancet* 1993; 341: 332–4.
- van Regenmortel M. Molecular dissection of protein antigens. In: van Regenmortel M ed. *Structure of antigens*. London: CRC Press, 1992:1–27.
- Schneider T, Lang AB, Carballido JM, Santamaria Babi LF, Dudler T, Kägi MK, Blaser K, Suter M. Human monoclonal or polyclonal antibodies recognize predominantly discontinuous epitopes on bee venom phospholipase A₂. *J Allergy Clin Immunol* 1994; 94:61–9.
- Liebers V, Baur X. Chironomidae haemoglobin Chi t I – characterization of an important inhalant allergen [Review]. *Clin Exp Allergy* 1994; 24:100–8.
- Janeway Jr CA, Medzhitov R, Pfeiffer C, Tao X, Bottomly K. Altered peptide ligands: Conformational changes in the TcR. *The Immunologist* 1995; 3:41–4.
- Kelso A. Th1 and Th2 subsets: paradigms lost? *Immunology Today* 1995; 16:374–9.
- Mohapatra SS, Cao Y, Ni H, Salo D. In pursuit of the ‘holy grail’: recombinant allergens and peptides as catalysts for the allergen-specific immunotherapy. *Allergy* 1995; 50: 37–44.
- Elsayed S, Apold J. Immunochemical analysis of cod fish allergen M: locations of the immunoglobulin binding sites as demonstrated by the native and synthetic peptides [Review]. *Allergy* 1983; 38:449–59.
- Elsayed S, Bennich H. The primary structure of allergen M from cod. *Scand J Immunol* 1975; 4:203–8.
- Hemmens VJ, Baldo BA, Underwood PA, Holen E, Elsayed S. Common antigenic and allergenic determinants on codfish proteins detected with mouse monoclonal IgG and human IgE antibodies. *Mol Immunol* 1989; 26:477–84.
- Dandeu JP, Rabillon J, Divanovic A, Carmi Leroy A, David B. Hydrophobic interaction chromatography for

- isolation and purification of Equ c I, the horse major allergen. *J Chromatogr* 1993; 621:23–31.
- 31 Fjeldsgaard BE, Paulsen BS. Comparison of IgE-binding antigens in horse dander and a mixture of horse hair and skin scrapings. *Allergy* 1993; 48:535–41.
 - 32 Lowenstein H, Markussen B, Weeke B. Isolation and partial characterization of three major allergens of horse hair and dandruff. *Int Arch Allergy Appl Immunol* 1976; 51:48–67.
 - 33 Schou C. Defining allergens of mammalian origin [Review]. *Clin Exp Allergy* 1993; 23:7–14.
 - 34 Lowenstein H. Characterization and chemical modification of isolated allergens from horse hair and dandruff. *Int Arch Allergy Appl Immunol* 1978; 57:349–57.
 - 35 Prahl P, Bucher D, Plesner T, Weeke B, Lowenstein H. Isolation and partial characterisation of three major allergens in an extract from cow hair and dander. *Int Arch Allergy Appl Immunol* 1982; 67:293–301.
 - 36 Sakaguchi M, Inouye S, Irie T, Miyazawa H, Watanabe M, Yasueda H, Shida T, Nitta H, Chapman MD, Schou C. Airborne cat (Fel d I), dog (Can f I), and mite (Der I and Der II) allergen levels in the homes of Japan. *J Allergy Clin Immunol* 1993; 92:797–802.
 - 37 Munir AK, Einarsson R, Schou C, Dreborg SK. Allergens in school dust. I. The amount of the major cat (Fel d I) and dog (Can f I) allergens in dust from Swedish schools is high enough to probably cause perennial symptoms in most children with asthma who are sensitized to cat and dog. *J Allergy Clin Immunol* 1993; 91:1067–74.
 - 38 van Milligen FJ, van Swieten P, Aalberse RC. Structure of the major cat allergen Fel d I in different allergen sources: an immunoblotting analysis with monoclonal antibodies against denatured Fel d I and human IgE. *Int Arch Allergy Immunol* 1992; 99:63–73.
 - 39 Morgenstern JP, Griffith IJ, Brauer AW et al. Amino acid sequence of Fel d I, the major allergen of the domestic cat: protein sequence analysis and cDNA cloning. *Proc Natl Acad Sci USA* 1991; 88:9690–4.
 - 40 Vailes LD, Li Y, Bao Y et al. Fine specificity of B-cell epitopes on *Felis domesticus* allergen I (Fel d I): effect of reduction and alkylation or deglycosylation on Fel d I structure and antibody binding. *J Allergy Clin Immunol* 1994; 93:22–33.
 - 41 Young RP, Dekker JW, Wordsworth BP et al. HLA-DR and HLA-DP genotypes and immunoglobulin E responses to common major allergens. [see comments]. *Clin Exp Allergy* 1994; 24:431–9.
 - 42 van 't Hof W, van Milligen FJ, van den Berg M et al. Epitope mapping of the cat (*Felis domesticus*) major allergen Fel d I by overlapping synthetic peptides and monoclonal antibodies against native and denatured Fel d I. *Allergy* 1993; 48:255–63.
 - 43 van Milligen FJ, van 't Hof W, van den Berg M, Aalberse RC. IgE epitopes on the cat (*Felis domesticus*) major allergen Fel d I: a study with overlapping synthetic peptides. *J Allergy Clin Immunol* 1994; 93:34–43.
 - 44 van Neerven RJ, van de Pol MM, van Milligen FJ, Jansen HM, Aalberse RC, Kapsenberg ML. Characterization of cat dander-specific T lymphocytes from atopic patients. *J Immunol* 1994; 152:4203–10.
 - 45 Rogers BL, Morgenstern JP, Garman RD, Bond JF, Kuo MC. Recombinant Fel d I: Expression, purification, IgE binding and reaction with cat-allergic human T cells. *Mol Immunol* 1993; 30:559–68.
 - 46 Griffith IJ, Craig S, Pollock J, Yu XB, Morgenstern JP, Rogers BL. Expression and genomic structure of the genes encoding FdI, the major allergen from the domestic cat. *Gene* 1992; 113:263–8.
 - 47 Schou C, Hansen GN, Lintner T, Lowenstein H. Assay for the major dog allergen, Can f I: investigation of house dust samples and commercial dog extracts. *J Allergy Clin Immunol* 1991; 88:847–53.
 - 48 Spitzauer S, Schweiger C, Anrather J, Ebner C, Scheiner O, Kraft D, Rumpold H. Characterisation of dog allergens by means of immunoblotting. *Int Arch Allergy Immunol* 1993; 100:60–7.
 - 49 Schou C, Svendsen UG, Lowenstein H. Purification and characterization of the major dog allergen, Can f I. *Clin Exp Allergy* 1991; 21:321–8.
 - 50 Ford AW, Kemeny DM. The allergens of dog. II. Identification and partial purification of a major dander allergen. *Clin Exp Allergy* 1992; 22:793–803.
 - 51 Spitzauer S, Schweiger C, Sperr WR et al. Molecular characterization of dog albumin as a cross-reactive allergen. *J Allergy Clin Immunol* 1994; 93:614–27.
 - 52 Ohman JL, Jr, Bloch KJ, Kendall S, Lowell FC. Allergens of mammalian origin IV Evidence for common allergens in cat and dog serum. *J Allergy Clin Immunol* 1976; 57:560–8.
 - 53 Price JA, Longbottom JL. Allergy to mice. II. Further characterization of two major mouse allergens (AG 1 and AG 3) and immunohistochemical investigations of their sources. *Clin Exp Allergy* 1990; 20:71–7.
 - 54 Ohman JL, Jr, Lowell FC, Bloch KJ. Allergens of mammalian origin. II. Characterization of allergens extracted from rat, mouse, guinea pig, and rabbit pelts. *J Allergy Clin Immunol* 1975; 55:16–24.
 - 55 Longbottom JL, Price JA. Allergy to laboratory animals: characterization and source of two major mouse allergens, Ag 1 and Ag 3. *Int Arch Allergy Appl Immunol* 1987; 82:450–2.
 - 56 Schumacher MJ, Tait BD, Holmes MC. Allergy to murine antigens in a biological research institute. *J Allergy Clin Immunol* 1981; 68:310–18.
 - 57 Lorusso JR, Moffat S, Ohman JL, Jr. Immunologic and biochemical properties of the major mouse urinary allergen (Mus m 1). *J Allergy Clin Immunol* 1986; 78:928–37.
 - 58 Longbottom JL. Crossed radio-immunoisoelectric focusing as a method of identifying isoallergens: identification of isoallergens in rat urine extracts. *J Immunol Meth* 1984; 68:297–304.
 - 59 Eggleston PA, Ansari AA, Ziemann B, Adkinson NF, Jr, Corn M. Occupational challenge studies with laboratory workers allergic to rats. *J Allergy Clin Immunol* 1990; 86:63–72.

- 60 Gordon S, Tee RD, Taylor AJ. Analysis of rat urine proteins and allergens by sodium dodecyl sulfate-polyacrylamide gel electrophoresis and immunoblotting. *J Allergy Clin Immunol* 1993; 92:298–305.
- 61 Lutsky I, Fink JN, Kidd J, Dahlberg MJ, Yunginger JW. Allergenic properties of rat urine and pelt extracts. *J Allergy Clin Immunol* 1985; 75:279–84.
- 62 Laperche Y, Lynch KR, Dolan KP, Feigelson P. Tissue-specific control of alpha 2u globulin gene expression: constitutive synthesis in the submaxillary gland. *Cell* 1983; 32:453–60.
- 63 Walls AF, Newman Taylor AJ, Longbottom JL. Allergy to guinea pigs: II. Identification of specific allergens in guinea pig dust by crossed radio-immuno-electrophoresis and investigation of the possible origin. *Clin Allergy* 1985; 15:535–46.
- 64 Price JA, Longbottom JL. Allergy to rabbits. II. Identification and characterization of a major rabbit allergen. *Allergy* 1988; 43:39–48.
- 65 Holen E, Elsayed S. Characterization of four major allergens of hen egg-white by IEF/SDS-PAGE combined with electrophoretic transfer and IgE-immunoautoradiography. *Int Arch Allergy Appl Immunol* 1990; 91:136–41.
- 66 Nisbet AD, Saundry RH, Moir AJ, Fothergill LA, Fothergill JE. The complete amino-acid sequence of hen ovalbumin. *Eur J Biochem* 1981; 115:335–45.
- 67 Kahlert H, Petersen A, Becker W-M, Schlaak M. Epitope analysis of the allergen ovalbumin (Gal d II) with monoclonal antibodies and patients' IgE. *Mol Immunol* 1992; 29:1191–201.
- 68 Elsayed S, Holen E, Haugstad MB. Antigenic and allergenic determinants of ovalbumin. II. The reactivity of the NH₂ terminal decapeptide. *Scand J Immunol* 1988; 27:587–91.
- 69 Shimojo N, Katsuki T, Coligan JE et al. Identification of the disease-related T cell epitope of ovalbumin and epitope-targeted T cell inactivation in egg allergy. *Int Arch Allergy Immunol* 1994; 105:155–61.
- 70 Hoffman DR. Immunochemical identification of the allergens in egg white. *J Allergy Clin Immunol* 1983; 71:481–6.
- 71 Goodman M, Braunitzer G, Kleinschmidt T, Aschauer H. The analysis of a protein-polymorphism. Evolution of monomeric and homodimeric haemoglobins (Erythrocytes) of *Chironomus thummi thummi* (insecta, diptera) Hoppe-Seyler's. *Z Physiol Chem* 1983; 354:205–17.
- 72 van Kampen V, Liebers V, Czuppon A, Baur X. Chironomidae hemoglobin allergy in Japanese, Swedish, and German populations. *Allergy* 1994; 49:9–12.
- 73 van Kampen V, Becker W-M, Chen Z et al. Analysis of B-cell epitopes in the N-terminal region of Chi t I component III using monoclonal antibodies. *Mol Immunol* 1994; 31:1133–40.
- 74 Liebers V, Raulf M, Mazur G, Modrow S, Baur X. Epitope mapping with peptides of Chi t I component III and immunomodulation of the Chi t immune response. *J Allergy Clin Immunol* 1993; 92:334–9.
- 75 Azhitskii GI, Azhitskii DG. [Development of a highly efficient method for separating bee venom components] Razrabotka vysokoeffektivnogo metoda razdeleniia komponentov pchel'nogo iada. *Ukr Biokhim Zh* 1993; 65:7–11.
- 76 Kuchler K, Gmachl M, Sippl MJ, Kreil G. Analysis of the cDNA for phospholipase A2 from honeybee venom glands. The deduced amino acid sequence reveals homology to the corresponding vertebrate enzymes. *Eur J Biochem* 1989; 184:249–54.
- 77 Scott DL, Otwinowski Z, Gelb MH, Sigler PB. Crystal structure of bee-venom phospholipase A2 in a complex with a transition-state analogue. *Science* 1990; 250:1563–6.
- 78 Lympny P, Kemeny DM, Welsh KI, Lee TH. An HLA-associated nonresponsiveness to mellitin: a component of bee venom. *J Allergy Clin Immunol* 1990; 86:160–70.
- 79 Dhillon M, Roberts C, Nunn T, Kuo M. Mapping human T cell epitopes on phospholipase A2: the major bee-venom allergen. *J Allergy Clin Immunol* 1992; 90:42–51.
- 80 Carballido JM, Carballido-Perrig N, Kägi MK, Meloen RH, Wuthrich B, Heusser CH, Blaser K. T cell epitope specificity in human allergic and nonallergic subjects to bee venom phospholipase A2. *J Immunol* 1993; 150:3582–91.
- 81 Dudler T, Chen WQ, Wang S et al. High-level expression in *Escherichia coli* and rapid purification of enzymatically active honey bee venom phospholipase A2. *Biochim Biophys Acta* 1992; 1165:201–10.
- 82 Gmachl M, Kreil G. Bee venom hyaluronidase is homologous to a membrane protein of mammalian sperm. *Proc Natl Acad Sci USA* 1993; 90:3569–73.
- 83 Vlasak R, Unger-Ullmann C, Kreil G, Frischauf AM. Nucleotide sequence of cloned cDNA coding for honeybee prepro-melittin. *Eur J Biochem* 1983; 135:123–6.
- 84 Schumacher MJ, Schmidt JO, Egen NB, Lowry JE. Quantity, analysis, and lethality of European and Africanized honey bee venoms. *Am J Trop Med Hyg* 1990; 43:79–86.
- 85 King TP, Kochoumian L, Joslyn A. Melittin-specific monoclonal and polyclonal IgE and IgG1 antibodies from mice. *J Immunol* 1984; 133:2668–73.
- 86 Kostrzhevskaja EG, Tarasenko AS, Veklich IuI, Shcherbatskaia NV. [Determination of melittin antigenic determinants in a model membrane] Opredelenie antigennykh determinant melittina v model'noi membrane. *Ukr Biokhim Zh* 1992; 64:22–9.
- 87 Piers KL, Brown MH, Hancock RE. Recombinant DNA procedures for producing small antimicrobial cationic peptides in bacteria. *Gene* 1993; 134:7–13.
- 88 Hoffman DR. Allergens in Hymenoptera venom. XXV: The amino acid sequences of antigen 5 molecules and the structural basis of antigenic cross-reactivity. *J Allergy Clin Immunol* 1993; 92:707–16.
- 89 Hoffman DR. Allergens in hymenoptera venom. XXVI: The complete amino acid sequences of two vespid venom phospholipases. *Int Arch Allergy Immunol* 1994; 104:184–90.

- 90 Lu G, Villalba M, Coscia MR, Hoffman DR, King TP. Sequence analysis and antigenic cross-reactivity of a venom allergen, antigen 5, from hornets, wasps, and yellow jackets. *J Immunol* 1993; 150:2823–30.
- 91 Soldatova L, Kochoumian L, King TP. Sequence similarity of a hornet (*D. maculata*) venom allergen phospholipase A1 with mammalian lipases. *FEBS Lett* 1993; 320:145–9.
- 92 Lu G, Kochoumian L, King TP. Sequence identity and antigenic cross-reactivity of white face hornet venom allergen, also a hyaluronidase, with other proteins. *J Biol Chem* 1995; 270:4457–65.
- 93 King TP, Moran D, Wang DF, Kochoumian L, Chait BT. Structural studies of a hornet venom allergen antigen 5, Dol m V and its sequence similarity with other proteins. *Protein Seq Data Anal* 1990; 3:263–6.
- 94 Fang KS, Vitale M, Fehlner P, King TP. cDNA cloning and primary structure of a white-face hornet venom allergen, antigen 5. *Proc Natl Acad Sci USA* 1988; 85: 895–9.
- 95 Donovan GR, Baldo BA, Sutherland S. Molecular cloning and characterization of a major allergen (Myr p I) from the venom of the Australian jumper ant, *Myrmecia pilosula*. *Biochim Biophys Acta* 1993; 1171:272–80.
- 96 Donovan GR, Street MD, Baldo BA et al. Identification of an IgE-binding determinant of the major allergen Myr p I from the venom of the Australian jumper ant *Myrmecia pilosula*. *Biochim Biophys Acta* 1994; 1204:48–52.
- 97 Hoffman DR. Fire ant venom allergy. *Allergy* 1995; 50:535–44.
- 98 Hoffman DR. Allergens in Hymenoptera venom. XXIV: the amino acid sequences of imported fire ant venom allergens Sol i II, Sol i III, and Sol i IV. *J Allergy Clin Immunol* 1993; 91:71–8.
- 99 Schmidt M, Walker RB, Hoffman DR, McConnell TJ. Nucleotide sequence of cDNA encoding the fire ant venom protein Sol i II. *FEBS Lett* 1993; 319:138–40.
- 100 Pollart SM, Mullins DE, Vailes LD, Hayden ML, Platts-Mills TA, Sutherland WM, Chapman MD. Identification, quantitation, and purification of cockroach allergens using monoclonal antibodies. *J Allergy Clin Immunol* 1991; 87:511–21.
- 101 Arruda LK, Vailes LD, Benjamin DC, Chapman MD. Molecular cloning of german cockroach (*Blattella germanica*) allergens. *Int Arch Allergy Immunol* 1995; 107: 295–7.
- 102 Helm RM, Brenner RJ, Williams LW, Burks AW. Isolation of the 36-kD German (*Blattella germanica*) cockroach allergen using fast protein liquid chromatography. *Int Arch Allergy Immunol* 1994; 103:59–66.
- 103 Chan Yeung M, Lam J, Ferguson A et al. Relationship between mite allergen levels in the homes, skintest reactivity and asthma. *Am Rev Resp Dis* 1993; 147:A459.
- 104 Fernandez Caldas E, Puerta L, Mercado D, Lockey RF, Caraballo LR. Mite fauna, Der p I, Der f I and *Blomia tropicalis* allergen levels in a tropical environment. *Clin Exp Allergy* 1993; 23:292–7.
- 105 Dilworth RJ, Chua KY, Simpson RJ et al. Sequence analysis of cDNA coding for a major house dust mite allergen, Der f I. *Clin Exp Allergy* 1991; 21:25–32.
- 106 Le Mao J, Weyer A, Mazie JC et al. Identification of allergenic epitopes on Der f I, a major allergen of *Dermatophagoides farinae*, using monoclonal antibodies. *Mol Immunol* 1992; 29:205–11.
- 107 Trudinger M, Chua KY, Thomas WR. cDNA encoding the major mite allergen Der f II. *Clin Exp Allergy* 1991; 21:33–7.
- 108 Yuuki T, Okumura Y, Ando T et al. Synthesis of biologically active recombinant Der f II. *Int Arch Allergy Appl Immunol* 1991; 94:354–6.
- 109 Nishiyama C, Yuuki T, Takai T, Okumura Y, Okudaira H. Determination of three disulfide bonds in a major house dust mite allergen, Der f II. *Int Arch Allergy Immunol* 1993; 101:159–66.
- 110 Ando T, Homma R, Ino Y, Ito G, Miyahara A, Yamakawa H, Iwaki M, Okumura Y, Suko M, Haida M. Is a trypsin-like protease of mites a Der f III allergen? *Arerugi — Jap J Allergology* 1992; 41:704–7.
- 111 Stewart GA, Ward LD, Simpson RJ, Thompson PJ. The group III allergen from the house dust mite *Dermatophagoides pteronyssinus* is a trypsin-like enzyme. *Immunology* 1992; 75:29–35.
- 112 Aki T, Kodama T, Fujikawa A et al. Immunochemical characterization of recombinant and native tropomyosins as a new allergen from the house dust mite, *Dermatophagoides farinae*. *J Allergy Clin Immunol* 1995; 96:74–83.
- 113 Aki T, Ono K, Paik S-J et al. Cloning and characterization of cDNA coding for a new allergen from the house dust mite, *Dermatophagoides farinae*. *Int Arch Allergy Immunol* 1994; 103:349–56.
- 114 Aki T, Ono A, Hidaka Y et al. Structure of IgE epitopes on a new 39-kD allergen molecule from the house dust mite, *Dermatophagoides farinae*. *Int Arch Allergy Immunol* 1994; 103:357–64.
- 115 Lind P, Hansen OC, Horn N. The binding of mouse hybridoma and human IgE antibodies to the major fecal allergen, Der p I, of *Dermatophagoides pteronyssinus*. Relative binding site location and species specificity studied by solid-phase inhibition assays with radiolabeled antigen. *J Immunol* 1988; 140:4256–62.
- 116 Hill MR, Newton MR, Hart BJ. Comparative IgE responses to extracts of five species of house dust mite, using western blotting. *Clin Exp Allergy* 1993; 23:110–16.
- 117 Tovey ER, Baldo BA. Localization of antigens and allergens in thin sections of the house dust mite, *Dermatophagoides pteronyssinus* (Acari: Pyroglyphidae). *J Med Entomol* 1990; 27:368–76.
- 118 Chua KY, Stewart GA, Thomas WR et al. Sequence analysis of cDNA coding for a major house dust mite allergen, Der p 1. Homology with cysteine proteases. *J Exp Med* 1988; 167:175–82.
- 119 Thomas WR, Stewart GA, Simpson RJ et al. Cloning and expression of DNA coding for the major house dust mite allergen Der p 1 in *Escherichia coli*. *Int Arch Allergy Appl Immunol* 1988; 85:127–9.
- 120 Topham CM, Srinivasan N, Thorpe CJ, Overington JP, Kalsheker NA. Comparative modelling of major house dust mite allergen Der p I: structure validation using an extended

- environmental amino acid propensity table. *Protein Eng* 1994; 7:869–94.
- 121 Johansson E, Johansson SG, Van Hage-Hamsten M. Allergenic characterization of *Acarus siro* and *Tyrophagus putrescentiae* and their crossreactivity with *Lepidoglyphus destructor* and *Dermatophagoides pteronyssinus*. *Clin Exp Allergy* 1994; 24:743–51.
 - 122 Kroidl R, Maasch HJ, Wahl R. Respiratory allergies (bronchial asthma and rhinitis) due to sensitization of type I allergy to red spider mite (*Panonychus ulmi* KOCH). *Clin Exp Allergy* 1992; 22:958–62.
 - 123 O'Hehir RE, Mach B, Berte C, Greenlaw R, Tiercy JM, Bal V, Lechler RI, Trowsdale J, Lamb JR. Direct evidence for a functional role of HLA-DRB1 and -DRB3 gene products in the recognition of *Dermatophagoides* spp (house dust mite) by helper T lymphocytes. *Int Immunol* 1990; 2:885–92.
 - 124 Greene WK, Chua KY, Stewart GA, Thomas WR. Antigenic analysis of group I house dust mite allergens using random fragments of Der p I expressed by recombinant DNA libraries. *Int Arch Allergy Appl Immunol* 1990; 92: 30–8.
 - 125 Greene WK, Thomas WR. IgE binding structures of the major house dust mite allergen Der p I. *Mol Immunol* 1992; 29:257–62.
 - 126 Yssel H, Johnson KE, Schneider PV, Wideman J, Terr A, Kastelein R, De Vries JE. T cell activation-inducing epitopes of the house dust mite allergen Der p I Proliferation and lymphokine production patterns by Der p I-specific CD4⁺ T cell clones. *J Immunol* 1992; 148:738–45.
 - 127 Chua KY, Doyle CR, Simpson RJ et al. Isolation of cDNA coding for the major mite allergen Der p II by IgE plaque immunoassay. *Int Arch Allergy Appl Immunol* 1990; 91:118–23.
 - 128 van 't Hof W, Driedijk PC, van den Berg M et al. Epitope mapping of the *Dermatophagoides pteronyssinus* house dust mite major allergen Der p II using overlapping synthetic peptides. *Mol Immunol* 1991; 28:1225–32.
 - 129 van 't Hof W, van den Berg M, Driedijk PC, Aalberse RC. Heterogeneity in the IgE binding to a peptide derived from the house dust mite allergen Der p II indicates that the IgE response is highly polyclonal. *Int Arch Allergy Immunol* 1993; 101:437–41.
 - 130 van Neerven RJ, Ringrose JH, Jansen HM, Aalberse RC, Wierenga EA, Kapsenberg ML. T cell epitopes of house dust mite major allergen Der p II. *J Immunol* 1993; 151:2326–35.
 - 131 O'Neill GM, Baldo BA. Intra-species cross-reactivity of house dust mite allergens separated by protein blotting and detected by selective elution of mite components and IgE antibodies. *Electrophoresis* 1993; 14:923–5.
 - 132 Smith WA, Chua KY, Kuo MC, Rogers BL, Thomas WR. Cloning and sequencing of the *Dermatophagoides pteronyssinus* group III allergen, Der p III. *Clin Exp Allergy* 1994; 24:220–8.
 - 133 Lake FR, Ward LD, Simpson RJ, Thompson PJ, Stewart GA. House dust mite-derived amylase: allergenicity and physicochemical characterization. *J Allergy Clin Immunol* 1991; 87:1035–42.
 - 134 Lake FR, Ward LD, Simpson RJ, Thompson PJ, Stewart GA. Allergenicity and physicochemical characterization of house dust mite derived amylase. *Int Arch Allergy Appl Immunol* 1991; 94:357–8.
 - 135 Tovey ER, Johnson MC, Roche AL, Cobon GS, Baldo BA. Cloning and sequencing of a cDNA expressing a recombinant house dust mite protein that binds human IgE and corresponds to an important low molecular weight allergen. *J Exp Med* 1989; 170:1457–62.
 - 136 Chapman MD. Structural and functional properties of indoor allergens. *Immunochemistry and Molecular Biology of Indoor allergens* 1994.
 - 137 Yasueda H, Mita H, Akiyama K, Shida T, Ando T, Sugiyama S, Yamakawa H. Allergens from *Dermatophagoides* mites with chymotryptic activity. *Clin Exp Allergy* 1993; 23:384–90.
 - 138 Shen HD, Chua KY, Lin WL, Hsieh KH, Thomas WR. Characterization of the house dust mite allergen Der p 7 by monoclonal antibodies. *Clin Exp Allergy* 1995; 25:416–22.
 - 139 Kent NA, Hill MR, Keen JN, Holland PW, Hart BJ. Molecular characterisation of group I allergen Eur m I from house dust mite *Euroglyphus maynei*. *Int Arch Allergy Immunol* 1992; 99:150–2.
 - 140 Tee RD. Allergy to storage mites [Review]. *Clin Exp Allergy* 1994; 24:636–40.
 - 141 Ventas P, Carreira J, Polo F. Purification and characterization of Lep d I, a major allergen from the mite *Lepidoglyphus destructor*. *Clin Exp Allergy* 1992; 22:454–60.
 - 142 Arruda LK, Fernandez-Caldas E, Naspitz CK, Montealegre F, Vailes LD, Chapman MD. Identification of *Blomia tropicalis* allergen Blo t 5 by cDNA cloning. *Int Arch Allergy Immunol* 1995; 107:456–7.
 - 143 Shanti KN, Martin BM, Nagpal S, Metcalfe DD, Rao PV. Identification of tropomyosin as the major shrimp allergen and characterization of its IgE-binding epitopes. *J Immunol* 1993; 151:5354–63.
 - 144 Daul CB, Slattery M, Reese G, Lehrer SB. Identification of the major brown shrimp (*Penaeus aztecus*) allergen as the muscle protein tropomyosin. *Int Arch Allergy Immunol* 1994; 105:49–55.
 - 145 Witteman AM, Akkerdaas JH, van Leeuwen J, van der Zee JS, Aalberse RC. Identification of a cross-reactive allergen (presumably tropomyosin) in shrimp, mite and insects. *Int Arch Allergy Immunol* 1994; 105:56–61.
 - 146 Reese G, Daul CB, Lehrer SB. Antigenic analysis (IgE and monoclonal antibodies) of the major shrimp allergen Pen a 1 (Tropomyosin) from *Penaeus aztecus*. *Int Arch Allergy Immunol* 1995; 107:245–7.
 - 147 Lin RY, Shen HD, Han SH. Identification and characterization of a 30 kd major allergen from *Parapenaeus fissurus*. *J Allergy Clin Immunol* 1993; 92:837–45.
 - 148 Leung PS, Chu KH, Chow WK, Ansari AA, Bandea CI, Kwan HS, Nagy SM, Gershwin ME. Cloning, expression, and

- primary structure of *Metapenaeus ensis* tropomyosin, the major heat-stable shrimp allergen. *J Allergy Clin Immunol* 1994; 94:882–90.
- 149 Christie JF, Dunbar B, Kennedy MW. The ABA-1 allergen of the nematode *Ascaris suum*: epitope stability, mass spectrometry, and N-terminal sequence comparison with its homologue in *Toxocara canis*. *Clin Exp Immunol* 1993; 92:125–32.
 - 150 Christie JF, Dunbar B, Davidson I, Kennedy MW. N-terminal amino acid sequence identity between a major allergen of *Ascaris lumbricoides* and *Ascaris suum*, and MHC-restricted IgE responses to it. *Immunology* 1990; 69:596–602.
 - 151 Larsen JN, Stroman P, Ipsen H. PCR based cloning and sequencing of isogenes encoding the tree pollen major allergen Car b I from *Carpinus betulus*, hornbeam. *Mol Immunol* 1992; 29:703–11.
 - 152 Ipsen H, Hansen OC. The NH₂-terminal amino acid sequence of the immunochemically partial identical major allergens of Alder (*Alnus glutinosa*) Aln g I, birch (*Betula verrucosa*) Bet v I, hornbeam (*Carpinus betulus*) Car b I and oak (*Quercus alba*) Que a I pollens. *Mol Immunol* 1991; 28:1279–88.
 - 153 Breiteneder H, Ferreira FD, Hoffmann-Sommergruber K, Ebner C, Breitenbach M, Rumpold H, Kraft D, Scheiner O. Four recombinant isoforms of Cor a I, the major allergen of hazel pollen, show different IgE-binding properties. *Eur J Biochem* 1993; 212:355–62.
 - 154 Ebner C, Ferreira FD, Hoffmann K et al. T cell clones specific for Bet v I, the major birch pollen allergen, crossreact with the major allergens of hazel, Cor a I, and alder, Aln g I. *Mol Immunol* 1993; 30:1323–9.
 - 155 Elsayed S, Holen E, Dybendal T. Synthetic allergenic epitopes from the amino-terminal regions of the major allergens of hazel and birch pollen. *Int Arch Allergy Appl Immunol* 1989; 89:410–15.
 - 156 Schenk S, Hoffmann-Sommergruber K, Breiteneder H, Ferreira FD, Fischer, Scheiner O, Kraft D, Ebner C. Four recombinant isoforms of Cor a 1, the major allergen of hazel pollen, show different reactivities with allergen-specific T-lymphocyte clones. *Eur J Biochem* 1994; 224:717–22.
 - 157 Breiteneder H, Pettenburger K, Bito A, Valenta R, Kraft D, Rumpold H, Scheiner O, Breitenbach M. The gene coding for the major birch pollen allergen Bet v 1, is highly homologous to a pea disease resistance response gene. *EMBO Journal* 1989; 8:1935–8.
 - 158 Fischer GF, Pickl WF, Fae I, Ebner C, Ferreira FD, Breiteneder H, Vikoukal E, Scheiner O, Kraft D. Association between IgE response against Bet v I, the major allergen of birch pollen, and HLA-DRB alleles. *Hum Immunol* 1992; 33:259–65.
 - 159 Sparholt SH, Georgsen J, Madsen HO, Svendsen UG, Schou C. Association between HLA-DRB3*0101 and immunoglobulin-E responsiveness to Bet v I. *Hum Immunol* 1994; 39:76–8.
 - 160 Ferreira FD, Hoffmann-Sommergruber K, Breiteneder H, Pettenburger K, Ebner C, Sommergruber W, Steiner R, Bohle B, Sperr WR, Valent P. Purification and characterization of recombinant Bet v I, the major birch pollen allergen. Immunological equivalence to natural Bet v I. *J Biol Chem* 1993; 268:19574–80.
 - 161 Valenta R, Duchêne M, Breitenbach M, Pettenburger K, Koller L, Rumpold H, Scheiner O, Kraft D. A low molecular weight allergen of white birch (*Betula verrucosa*) is highly homologous to human profilin. *Int Arch Allergy Appl Immunol* 1991; 94:368–70.
 - 162 Valenta R, Duchêne M, Ebner C, Valent P, Sillaber C, Deviller P, Ferreira FD, Tejkl M, Edelmann H, Kraft D. Profilins constitute a novel family of functional plant pan-allergens. *J Exp Med* 1992; 175:377–85.
 - 163 van Ree R, Voitenko V, van Leeuwen WA, Aalberse RC. Profilin is a cross-reactive allergen in pollen and vegetable foods. *Int Arch Allergy Immunol* 1992; 98:97–104.
 - 164 Seiberler S, Scheiner O, Kraft D, Lonsdale D, Valenta R. Characterization of a birch pollen allergen, Bet v III, representing a novel class of Ca²⁺ binding proteins: specific expression in mature pollen and dependence of patients' IgE binding on protein-bound Ca²⁺. *EMBO Journal* 1994; 13:3481–6.
 - 165 Breiteneder H, Ferreira FD, Reikerstorfer A, Duchêne M, Valenta R, Hoffmann-Sommergruber K, Ebner C, Breitenbach M, Kraft D, Scheiner O. Complementary DNA cloning and expression in *Escherichia coli* of Aln g I, the major allergen in pollen of alder (*Alnus glutinosa*). *J Allergy Clin Immunol* 1992; 90:909–17.
 - 166 Kos T, Hoffmann-Sommergruber K, Ferreira FD, Hirschwehr R, Ahorn H, Horak F, Jager S, Sperr W, Kraft D, Scheiner O. Purification, characterization and N-terminal amino acid sequence of a new major allergen from European chestnut pollen—Cas s 1. *Biochem Biophys Res Commun* 1993; 196:1086–92.
 - 167 Burks AW, Cockrell G, Connaughton C, Helm RM. Epitope specificity and immunoaffinity purification of the major peanut allergen, Ara h I. *J Allergy Clin Immunol* 1994; 93:743–50.
 - 168 Burks AW, Cockrell G, Connaughton C, Karpas A, Helm RM. Epitope specificity of the major peanut allergen, Ara h II. *J Allergy Clin Immunol* 1995; 95:607–11.
 - 169 Gonzalez R, Polo F, Zapatero L, Caravaca F, Carreira J. Purification and characterization of major inhalant allergens from soybean hulls. *Clin Exp Allergy* 1992; 22:748–55.
 - 170 Dennis MS, Light DR. Rubber elongation factor from *Hevea brasiliensis*. Identification, characterization, and role in rubber biosynthesis. *J Biol Chem* 1989; 264:18608–17.
 - 171 Czuppon AB, Chen Z, Rennert S, Engelke T, Meyer HE, Heber M, Baur X. The rubber elongation factor of rubber trees (*Hevea brasiliensis*) is the major allergen in latex. *J Allergy Clin Immunol* 1993; 92:690–7.
 - 172 Dennis MS, Henzel WJ, Bell J, Kohr W, Light DR. Amino acid sequence of rubber elongation factor protein associated with rubber particles in *Hevea* latex. *J Biol Chem* 1989; 264:18618–26.
 - 173 Rafnar T, Griffith IJ, Kuo MC, Bond JF, Rogers BL, Klapper DG. Cloning of Amb al (antigen E), the major allergen family of short ragweed pollen. *J Biol Chem* 1991; 266:1229–36.

- 174 Rogers BL, Morgenstern JP, Griffith IJ, Yu XB, Counsell CM, Brauer AW, King TP, Garman RD, Kuo MC. Complete sequence of the allergen Amb a II Recombinant expression and reactivity with T cells from ragweed allergic patients. *J Immunol* 1991; 147:2547–52.
- 175 Olson JR, Klapper DG. Two major human allergenic sites on ragweed pollen allergen antigen E identified by using monoclonal antibodies. *J Immunol* 1986; 136:2109–15.
- 176 Smith JJ, Olson JR, Klapper DG. Monoclonal antibodies to denatured ragweed pollen allergen Amb a I: characterization, specificity for the denatured allergen, and utilization for the isolation of immunogenic peptides of Amb a I. *Mol Immunol* 1988; 25:355–65.
- 177 Bond JF, Garman RD, Keating KM, Briner TJ, Rafnar T, Klapper DG, Rogers BL. Multiple Amb a I allergens demonstrate specific reactivity with IgE and T cells from ragweed-allergic patients. *J Immunol* 1991; 146:3380–5.
- 178 Kuo MC, Zhu XJ, Koury R, Griffith IJ, Klapper DG, Bond JF, Rogers BL. Purification and immunochemical characterization of recombinant and native ragweed allergen Amb a II. *Mol Immunol* 1993; 30:1077–87.
- 179 Klapper DG, Goodfriend L, Capra JD. Amino acid sequence of ragweed allergen Ra3. *Biochemistry* 1980; 19:5729–34.
- 180 Atassi MZ, Atassi H. Antibody and T-lymphocyte recognition regions on ragweed allergen Amb a III (Ra 3). In: Sehon A, Kraft D, Kunkel G. eds. *Epitopes of Atopic Allergens* Berlin: The UCB Institute of Allergy, 1990:33–40.
- 181 Roebber M, Klapper DG, Goodfriend L, Bias WB, Hsu SH, Marsh DG. Immunochemical and genetic studies of Amb t V (Ra5G), an Ra5 homologue from giant ragweed pollen. *J Immunol* 1985; 134:3062–9.
- 182 Ghosh B, Perry MP, Rafnar T, Marsh DG. Cloning and expression of immunologically active recombinant Amb a V allergen of short ragweed (*Ambrosia artemisiifolia*) pollen. *J Immunol* 1993; 150:5391–9.
- 183 Mole LE, Goodfriend L, Lapkoff CB, Kehoe JM, Capra JD. The amino acid sequence of ragweed pollen allergen Ra5. *Biochemistry* 1975; 14:1216–20.
- 184 Rafnar T, Ghosh B, Metzler WJ, Huang SK, Perry MP, Mueller L, Marsh DG. Expression and analysis of recombinant Amb aV and Amb tV allergens Comparison with native proteins by immunological assays and NMR spectroscopy. *J Biol Chem* 1992; 267:21119–23.
- 185 Marsh DG, Zwollo P, Huang SK, Ansari AA. Molecular genetics of human immune responsiveness to allergens [Review]. *Ciba Foundation Symposium* 1989; 147:171–83; discussion 183–7.
- 186 Marsh DG, Freidhoff LR, Ehrlich-Kautzky E, Bias WB, Roebber M. Immune responsiveness to *Ambrosia artemisiifolia* (short ragweed) pollen allergen Amb a VI (Ra6) is associated with HLA-DR5 in allergic humans. *Immunogenetics* 1987; 26:230–6.
- 187 Schreiner O, Kraft D. Basic and practical aspects of recombinant allergens. *Allergy* 1995; 50:384–91.
- 188 Ghosh B, Rafnar T, Perry MP, Bassolino-Klimas D, Metzler WJ, Klapper DG, Marsh DG. Immunologic and molecular characterization of Amb p V allergens from *Ambrosia psilostachya* (western Ragweed) pollen. *J Immunol* 1994; 152:2882–9.
- 189 Goodfriend L, Choudhury AM, Klapper DG, Coulter KM, Dorval G, Carpio J, Osterland CK. Ra5G, a homologue of Ra5 in giant ragweed pollen: isolation, HLA-DR-associated activity and amino acid sequence. *Mol Immunol* 1985; 22:899–906.
- 190 Ghosh B, Perry MP, Marsh DG. Cloning the cDNA encoding the Amb t V allergen from giant ragweed (*Ambrosia trifida*) pollen. *Gene* 1991; 101:231–8.
- 191 Nilsen BM, Grimsoen A, Paulsen BS. Identification and characterization of important allergens from mugwort pollen by IEF, SDS-PAGE and immunoblotting. *Mol Immunol* 1991; 28:733–42.
- 192 Nilsen BM, Sletten K, Paulsen BS, O'Neill M, van Halbeek H. Structural analysis of the glycoprotein allergen Art v II from the pollen of mugwort (*Artemisia vulgaris* L.). *J Biol Chem* 1991; 266:2660–8.
- 193 Monsalve RI, Gonzalez de la Pena MA, Menendez-Arias L, Lopez-Otin C, Villalba M, Rodriguez R. Characterization of a new oriental-mustard (*Brassica juncea*) allergen, Bra j IE: detection of an allergenic epitope. *Biochem J* 1993; 293:625–32.
- 194 Menendez-Arias L, Moneo I, Dominguez J, Rodriguez R. Primary structure of the major allergen of yellow mustard (*Sinapis alba* L.) seed, Sin a I. *Eur J Biochem* 1988; 177:159–66.
- 195 Gonzalez de la Pena MA, Villalba M, Garcia-Lopez JL, Rodriguez R. Cloning and expression of the major allergen from yellow mustard seeds, Sin a I. *Biochem Biophys Res Commun* 1993; 190:648–53.
- 196 Menendez-Arias L, Dominguez J, Moneo I, Rodriguez R. Epitope mapping of the major allergen from yellow mustard seeds, Sin a I. *Mol Immunol* 1990; 27:143–50.
- 197 Villalba M, Batanero E, Lopez-Otin C, Sanchez LM, Monsalve RI, Gonzalez de la Pena MA, Lahoz C, Rodriguez R. The amino acid sequence of Ole e I, the major allergen from olive tree (*Olea europaea*) pollen. *Eur J Biochem* 1993; 216:863–9.
- 198 Batanero E, Villalba M, Rodriguez R. Glycosylation site of the major allergen from olive tree pollen Allergenic implications of the carbohydrate moiety. *Mol Immunol* 1994; 31:31–7.
- 199 Lombardero M, Barbas JA, Moscoso del Prado J, Carreira J. cDNA sequence analysis of the main olive allergen, Ole e I. *Clin Exp Allergy* 1994; 24:765–70.
- 200 Martin-Orozco E, Cardaba B, del Pozo V, de Andres B, Villalba M, Gallardo S, Rodriguez-Garcia MI, Fernandez MC, Alche JD, Rodriguez R. Ole e I: epitope mapping, cross-reactivity with other oleaceae pollens and ultrastructural localization. *Int Arch Allergy Immunol* 1994; 104:160–70.
- 201 Cardaba B, Vilches C, Martin E, de Andres B, del Pozo V, Hernandez D, Gallardo S, Fernandez JC, Villalba M, Rodriguez R. DR7 and DQ2 are positively associated with immunoglobulin-E response to the main antigen of olive pollen (Ole e I) in allergic patients. *Hum Immunol* 1993; 38:293–9.

- 202 Villalba M, Batanero E, Monsalve RI, Gonzalez de la Pena MA, Lahoz C, Rodriguez R. Cloning and expression of Ole e I, the major allergen from olive tree pollen. Polymorphism analysis and tissue specificity. *J Biol Chem* 1994; 269:15217–22.
- 203 Batanero E, Villalba M, Lopez-Otin C, Rodriguez R. Isolation and characterization of an olive allergen-like protein from lilac pollen. Sequence analysis of three cDNA encoding protein isoforms. *Eur J Biochem* 1994; 221:187–93.
- 204 Ayuso R, Carreira J, Lombardero M, Duffort O, Peris A, Basomba A, Polo F. Isolation by mAb based affinity chromatography of two Pari j I isoallergens. Comparison of their physicochemical, immunochemical and allergenic properties. *Mol Immunol* 1993; 30:1347–54.
- 205 Costa MA, Colombo P, Izzo V, Kennedy H, Venturella S, Cocchiara R, Mistrello G, Falagiani P, Geraci D. cDNA cloning, expression and primary structure of Pari j I, a major allergen of *Parietaria judaica* pollen. *FEBS Letters* 1994; 341:182–6.
- 206 Mucci N, Liberatore P, Federico R, Forlani F, Di Felice G, Afferni C, Tinghino R, De Cesare F, Pini C. Role of carbohydrate moieties in cross-reactivity between different components of *Parietaria judaica* pollen extract. *Allergy* 1992; 47:424–30.
- 207 Oreste U, Coscia MR, Scotto d, A, Santonastaso V, Ruffilli A. Purification and characterization of Pari o I, major allergen of *Parietaria officinalis* pollen. *Int Arch Allergy Appl Immunol* 1991; 96:19–27.
- 208 Petersen A, Becker W-M, Schlaak M. Characterization of grass group I allergens in timothy grass pollen. *J Allergy Clin Immunol* 1993; 92:789–96.
- 209 Laffer S, Valenta R, Vrtala S, Susani M, van Ree R, Kraft D, Scheiner O, Duchene M. Complementary DNA cloning of the major allergen Phl p I from timothy grass (*Phleum pratense*); recombinant Phl p I inhibits IgE binding to group I allergens from eight different grass species. *J Allergy Clin Immunol* 1994; 94:689–98.
- 210 Petersen A, Bufe A, Schramm G, Schlaak M, Becker W-M. Studies on the major allergen Phl p VI on the protein and cDNA level. *J Allergy Clin Immunol* 1994; 93:206.
- 211 Suphioglu C, Singh MB, Knox RB. Peptide mapping analysis of group I allergens of grass pollens. *Int Arch Allergy Immunol* 1993; 102:144–51.
- 212 Valenta R, Vrtala S, Ebner C, Kraft D, Scheiner O. Diagnosis of grass pollen allergy with recombinant timothy grass (*Phleum pratense*) pollen allergens. *Int Arch Allergy Immunol* 1992; 97:287–94.
- 213 Dolecek C, Vrtala S, Laffer S, Steinberger P, Kraft D, Scheiner O, Valenta R. Molecular characterization of Phl p II, a major timothy grass (*Phleum pratense*) pollen allergen. *FEBS Lett* 1993; 335:299–304.
- 214 Lowenstein H. Isolation and partial characterization of three allergens of timothy pollen. *Allergy* 1978; 33:30–41.
- 215 Haavik S, Paulsen BS, Wold JK. Glycoprotein allergens in pollen of timothy II Isolation and characterization of a basic glycoprotein allergen. *Int Arch Allergy Appl Immunol* 1985; 78:260–8.
- 216 Bufe A, Schramm G, Keown MB, Schlaak M, Becker W-M. Major allergen Phl p Vb in timothy grass is a novel pollen RNase. *FEBS Lett* 1995; 363:6–12.
- 217 Matthiesen F, Lowenstein H. Group V allergens in grass pollens. I. Purification and characterization of the group V allergen from *Phleum pratense* pollen, Phl p V. *Clin Exp Allergy* 1991; 21:297–307.
- 218 Petersen A, Becker W-M, Schlaak M. Epitope analysis of isoforms of the major allergen Phl p V by fingerprinting and microsequencing. *Clin Exp Allergy* 1994; 24:250–6.
- 219 Vrtala S, Sperr WR, Reimitzer I et al. cDNA cloning of a major allergen from timothy grass (*Phleum pratense*) pollen; characterization of the recombinant Phl p V allergen. *J Immunol* 1993; 151:4773–81.
- 220 Matthiesen F, Lowenstein H. Group V allergens in grass pollens. II. Investigation of group V allergens in pollens from 10 grasses. *Clin Exp Allergy* 1991; 21:309–20.
- 221 Bufe A, Becker W-M, Schramm G et al. Major allergen Phl p Va (timothy grass) bears at least two different IgE reactive epitopes. *J Allergy Clin Immunol* 1994; 94:173.
- 222 Valenta R, Ball T, Vrtala S, Duchêne M, Kraft D, Scheiner O. cDNA cloning and expression of timothy grass (*Phleum pratense*) pollen profilin in *Escherichia coli*: comparison with birch pollen profilin. *Biochem Biophys Res Commun* 1994; 199:106–18.
- 223 Perez M, Ishioka GY, Walker LE, Chesnut RW. cDNA cloning and immunological characterization of the rye grass allergen Lol p I. *J Biol Chem* 1990; 265:16210–15.
- 224 Singh MB, Hough T, Theerakulpisut P, Avjioglu A, Davies S, Smith PM, Taylor P, Simpson RJ, Ward LD, McCluskey J et al. Isolation of cDNA encoding a newly identified major allergenic protein of rye-grass pollen: intracellular targeting to the amyloplast. *Proc Natl Acad Sci USA* 1991; 88:1384–8.
- 225 Griffith IJ, Smith PM, Pollock J, Theerakulpisut P, Avjioglu A, Davies S, Hough T, Singh MB, Simpson RJ, Ward LD et al. Cloning and sequencing of Lol p I, the major allergenic protein of rye-grass pollen. *FEBS Letters* 1991; 279:210–15.
- 226 Ansari AA, Shenbagamurthi P, Marsh DG. Complete primary structure of a *Lolium perenne* (perennial rye grass) pollen allergen, Lol p III: comparison with known Lol p I and II sequences. *Biochemistry* 1989; 28:8665–70.
- 227 Ansari AA, Kihara TK, Marsh DG. Immunochemical studies of *Lolium perenne* (rye grass) pollen allergens, Lol p I, II, and III. *J Immunol* 1987; 139:4034–41.
- 228 Bungy-Poor-Fard GA, Latchman Y, Rodda S, Geysen M, Roitt I, Brostoff J. T cell epitopes of the major fraction of rye grass *Lolium perenne* (Lol p I) defined using overlapping peptides in vitro and in vivo. I. Isoallergen clone1A. *Clin Exp Immunol* 1993; 94:111–16.
- 229 Spiegelberg HL, Beck L, Stevenson DD, Ishioka GY. Recognition of T cell epitopes and lymphokine secretion by rye grass allergen *Lolium perenne* I-specific human T cell clones. *J Immunol* 1994; 152:4706–11.
- 230 Roberts AM, van Ree R, Cardy SM, Bevan LJ, Walker MR. Recombinant pollen allergens from *Dactylis glomerata*: preliminary evidence that human IgE cross-reactivity between

- Dac g II and Lol p I/II is increased following grass pollen immunotherapy. *Immunology* 1992; 76:389–96.
- 231 Ansari AA, Shenbagamurthi P, Marsh DG. Complete amino acid sequence of a *Lolium perenne* (perennial rye grass) pollen allergen, Lol p II. *J Biol Chem* 1989; 264: 11181–5.
 - 232 Sidoli A, Tamborini E, Giuntini I, Levi S, Volonte G, Paini C, Lalla C, Siccardi AG, Baralle FE, Galliani S. Cloning, expression, and immunological characterization of recombinant *Lolium perenne* allergen Lol p II. *J Biol Chem* 1993; 268:21819–25.
 - 233 Ansari AA, Freidhoff LR, Marsh DG. Molecular genetics of human immune responsiveness to *Lolium perenne* (rye) allergen, Lol p III [published erratum appears in *Int Arch Allergy Appl Immunol* 1989; Sep; 50 (9): following 424] *Int Arch Allergy Appl Immunol* 1989; 88:164–9.
 - 234 Baskar S, Parronchi P, Mohapatra SS, Romagnani S, Ansari AA. Human T cell responses to purified pollen allergens of the grass, *Lolium perenne*. Analysis of relationship between structural homology and T cell recognition. *J Immunol* 1992; 148:2378–83.
 - 235 Ansari AA, Freidhoff LR, Meyers DA, Bias WB, Marsh DG. Human immune responsiveness to *Lolium perenne* pollen allergen Lol p III (rye III) is associated with HLA-DR3 and DR5 [published erratum appears in *Hum Immunol* 1989; Oct; 26(2):149] *Hum Immunol* 1989; 25:59–71.
 - 236 Ekramoddoullah AK, Kisil FT, Sehon AH. Immunochemical characterization of a high molecular weight basic allergen (HMBA) of rye grass (*Lolium perenne*) pollen. *Mol Immunol* 1983; 20:465–73.
 - 237 Jaggi KS, Ekramoddoullah AK, Kisil FT. Allergenic fragments of ryegrass (*Lolium perenne*) pollen allergen Lol p IV. *Int Arch Allergy Appl Immunol* 1989; 89:342–8.
 - 238 Jaggi KS, Ekramoddoullah AK, Kisil FT, Dzuba-Fischer J, Rector ES, Sehon AH. Identification of two distinct allergenic sites on ryegrass-pollen allergen, Lol p IV. *J Allergy Clin Immunol* 1989; 83:845–52.
 - 239 Becker W-M, Petersen A, Bufer A, Schramm G, Schlaak M. Clinical use of synthetic peptides of grass pollen and other allergens. In: Johansson SGO ed. *Progress in Allergy and Clinical Immunology*. Seattle, Toronto, Bern, Göttingen: Hogrefe & Huber Publishers, 1995:220–5.
 - 240 Ong EK, Griffith IJ, Knox RB, Singh MB. Cloning of a cDNA encoding a group-V (group-IX) allergen isoform from rye-grass pollen that demonstrates specific antigenic immunoreactivity. *Gene* 1993; 134:235–40.
 - 241 Klysner S, Welinder KG, Lowenstein H, Matthiesen F. Group V allergens in grass pollens: IV. Similarities in amino acid compositions and NH₂-terminal sequences of the group V allergens from *Lolium perenne*, *Poa pratensis* and *Dactylis glomerata*. *Clin Exp Allergy* 1992; 22:491–7.
 - 242 van Ree R, Driessen MN, van Leeuwen WA, Stapel SO, Aalberse RC. Variability of crossreactivity of IgE anti-bodies to group I and V allergens in eight grass pollen species. *Clin Exp Allergy* 1992; 22:611–17.
 - 243 Ong EK, Knox RB, Singh MB. Mapping of the antigenic and allergenic epitopes of Lol p VB using gene fragmentation. *Mol Immunol* 1995; 32:295–302.
 - 244 Ansari AA, Killoran EA, Marsh DG. An investigation of human immune response to perennial ryegrass (*Lolium perenne*) pollen cytochrome c (Lol p X). *J Allergy Clin Immunol* 1987; 80:229–35.
 - 245 Ekramoddoullah AK, Kisil FT, Sehon AH. Allergenic cross reactivity of cytochrome c from Kentucky Blue grass and perennial ryegrass pollens. *Mol Immunol* 1982; 19:1527.
 - 246 van Ree R, Hoffman DR, van Dijk W, Brodard V, Mahieu K, Koeleman CA, Grande M, van Leeuwen WA, Aalberse RC. Lol p XI, a new major grass pollen allergen, is a member of a family of soybean trypsin inhibitor-related proteins. *J Allergy Clin Immunol* 1995; 95:970–8.
 - 247 Mecheri S, Peltre G, David B. Purification and characterization of a major allergen from *Dactylis glomerata* pollen: the Ag Dg1. *Int Arch Allergy Appl Immunol* 1985; 78: 283–9.
 - 248 Mourad W, Mecheri S, Peltre G, David B, Hebert J. Study of the epitope structure of purified Dac g I and Lol p I, the major allergens of *Dactylis glomerata* and *Lolium perenne* pollens, using monoclonal antibodies. *J Immunol* 1988; 141: 3486–91.
 - 249 Roberts AM, Bevan LJ, Flora PS, Jepson I, Walker MR. Nucleotide sequence of cDNA encoding the group II allergen of cocksfoot/orchard grass (*Dactylis glomerata*), Dac g II. *Allergy* 1993; 48:615–23.
 - 250 Walsh DJ, Matthews JA, Denmeade R, Maxwell P, Davidson M, Walker MR. Monoclonal antibodies to proteins from cocksfoot grass (*Dactylis glomerata*) pollen: isolation and N-terminal sequence of a major allergen. *Int Arch Allergy Appl Immunol* 1990; 91:419–25.
 - 251 Lin ZW, Ekramoddoullah AK, Kisil FT, Hebert J, Mourad W. Isolation and characterization of Poa p I allergens of Kentucky bluegrass pollen with a murine monoclonal anti-Lol p I antibody. *Int Arch Allergy Appl Immunol* 1988; 87: 294–300.
 - 252 Esch RE, Klapper DG. Isolation and characterization of a major cross-reactive grass group I allergenic determinant. *Mol Immunol* 1989; 26:557–61.
 - 253 Lin ZW, Ekramoddoullah AK, Jaggi KS, Dzuba-Fischer J, Rector E, Kisil FT. Mapping of epitopes on Poa p I and Lol p I allergens with monoclonal antibodies. *Int Arch Allergy Appl Immunol* 1990; 91:217–23.
 - 254 Silvanovich A, Astwood JD, Zhang L, Olsen E, Kisil FT, Sehon AH, Mohapatra SS, Hill R. Nucleotide sequence analysis of three cDNAs coding for Poa p IX isoallergens of Kentucky bluegrass pollen. *J Biol Chem* 1991; 266:1204–10.
 - 255 Olsen E, Zhang L, Hill RD, Kisil FT, Sehon AH, Mohapatra SS. Identification and characterization of the Poa p IX group of basic allergens of Kentucky bluegrass pollen. *J Immunol* 1991; 147:205–11.
 - 256 Zhang L, Olsen E, Kisil FT, Hill RD, Sehon AH, Mohapatra SS. Mapping of antibody binding epitopes of a

- recombinant Poa p IX allergen. *Mol Immunol* 1992;29: 1383–9.
- 257 Matthiesen F, Schumacher MJ, Lowenstein H. Characterization of the major allergen of *Cynodon dactylon* (Bermuda grass) pollen, Cyn d I. *J Allergy Clin Immunol* 1991; 88:763–74.
 - 258 Smith PM, Singh MB, Knox RB. Characterization and cloning of the major allergen of bermuda grass, Cyn d I. In: Kraft D, Sehon A. eds. *Molecular biology and immunology of allergens*. Boca Raton. Ann Arbor. London Tokyo: CRC Press, 1993:157–60.
 - 259 Mena M, Sanchez-Monge R, Gomez L, Salcedo G, Carbonero P. A major barley allergen associated with baker's asthma disease is a glycosylated monomeric inhibitor of insect alpha-amylase: cDNA cloning and chromosomal location of the gene. *Plant Mol Biol* 1992;20: 451–8.
 - 260 Astwood JD, Mohapatra SS, Ni H, Hill RD. Pollen allergen homologues in barley and other crop species. *Clin Exp Allergy* 1995; 25:66–72.
 - 261 Horner WE, Reese G, Lehrer SB. Identification of the allergen Psi c 2 from the basidiomycete *Psilocybe cubensis* as a fungal cyclophilin. *Int Arch Allergy Immunol* 1995; 107:298–300.
 - 262 Suphioglu C, Singh MB, Simpson RJ, Ward LD, Knox RB. Identification of canary grass (*Phalaris aquatica*) pollen allergens by immunoblotting: IgE and IgG antibody-binding studies. *Allergy* 1993; 48:273–81.
 - 263 Broadwater AH, Rubinstein AL, Chay CH, Klapper DG, Bedinger PA. Zea m I, the maize homolog of the allergen-encoding Lol p I gene of rye grass. *Gene* 1993; 131:227–30.
 - 264 Staiger CJ, Goodbody KC, Hussey PJ, Valenta R, Drobak BK, Lloyd CW. The profilin multigene family of maize: differential expression of three isoforms. *Plant J* 1993; 4: 631–41.
 - 265 Kawashima T, Taniai M, Taniguchi Y et al. Antigenic analyses of Sugi basic protein by monoclonal antibodies: I. Distribution and characterization of B-cell-tropic epitopes of Cry jI molecules. *Int Arch Allergy Immunol* 1992; 98:110–7.
 - 266 Taniguchi Y, Ono A, Sawatani M et al. Cry j I, a major allergen of Japanese cedar pollen, has pectate lyase enzyme activity. *Allergy* 1995; 50:90–3.
 - 267 Sone T, Komiyama N, Shimizu K et al. Cloning and sequencing of cDNA coding for Cry j I, a major allergen of Japanese cedar pollen. *Biochem Biophys Res Commun* 1994; 199:619–25.
 - 268 Taniai M, Kayano T, Takakura R, Yamamoto S, Usui M, Ando S, Kurimoto M, Panzani R, Matuhasi T. Epitopes on Cry jI and Cry j II for the human IgE antibodies cross-reactive between *Cupressus sempervirens* and *Cryptomeria japonica* pollen. *Mol Immunol* 1993; 30:183–9.
 - 269 Kawashima T, Taniai M, Usui M et al. Antigenic analyses of Sugi basic protein by monoclonal antibodies: II. Detection of immunoreactive fragments in enzyme-cleaved Cry j I. *Int Arch Allergy Immunol* 1992; 98:118–26.
 - 270 Komiyama N, Sone T, Shimizu K, Morikubo K, Kino K. cDNA cloning and expression of Cry j II the second major allergen of Japanese cedar pollen. *Biochem Biophys Res Commun* 1994; 201:1021–8.
 - 271 Sakaguchi M, Inouye S, Taniai M et al. Identification of the second major allergen of Japanese cedar pollen. *Allergy* 1990; 45:309–12.
 - 272 Arruda LK, Mann BJ, Chapman MD. Selective expression of a major allergen and cytotoxin, Asp f I, in *Aspergillus fumigatus*. Implications for the immunopathogenesis of *Aspergillus*-related diseases. *J Immunol* 1992; 149: 3354–9.
 - 273 el-Dahr JM, Fink R, Selden R et al. Development of immune responses to *Aspergillus* at an early age in children with cystic fibrosis. *Am J Resp Crit Care Med* 1994; 150:1513–8.
 - 274 Sporik RB, Arruda LK, Woodfolk J, Chapman MD, Platts-Mills TA. Environmental exposure to *Aspergillus fumigatus* allergen (Asp f I). *Clin Exp Allergy* 1993; 23:326–31.
 - 275 Moser M, Cramer R, Menz G et al. Cloning and expression of recombinant *Aspergillus fumigatus* allergen I/a (rAsp f I/a) with IgE binding and type I skin test activity. *J Immunol* 1992; 149:454–60.
 - 276 Baur X, Chen Z, Sander I. Isolation and denomination of an important allergen in baking additives: alpha-amylase from *Aspergillus oryzae* (Asp o II). *Clin Exp Allergy* 1994; 24:465–70.
 - 277 Toda H, Kondo K, Narita K. The complete amino acid sequence of Taka-amylase A. *Proc Japan Acad* 1982; 58:208–12.
 - 278 Tada S, Iimura Y, Gomi K et al. Cloning and nucleotide sequence of the genomic Taka-amylase A gene of *Aspergillus oryzae*. *Agric Biol Chem* 1989; 53:593–9.
 - 279 Rihs H-P, Lipps P, May-Taube K, Welticke B, Baur X. Untersuchungen zur genetischen Prädisposition für die Soforttyp-Sensibilisierung auf *Aspergillus* Amylase (Asp o I) und ein 59 kD Mehlallergen. *Allergologie* 1994; 17:168–70.
 - 280 Randez-Gil F, Sanz P. Expression of *Aspergillus oryzae* alpha-amylase gene in *Saccharomyces cerevisiae*. *FEMS Microbiol Lett* 1993; 112:119–23.
 - 281 Paris S, Debeaupuis JP, Prevost MC, Casotto M, Latge JP. The 31 kd major allergen, Alt a I1563, of *Alternaria alternata*. *J Allergy Clin Immunol* 1991; 88:902–8.
 - 282 Kleine-Tebbe J, Worm M, Jeep S et al. Predominance of the major allergen (Alt a I) in *Alternaria* sensitized patients. *Clin Exp Allergy* 1993; 23:211–8.
 - 283 Shen HD, Choo KB, Lee HH. The 40-kilodalton allergen of *Candida albicans* is an alcohol dehydrogenase: molecular cloning and immunological analysis using monoclonal antibodies. *Clin Exp Allergy* 1991; 21:675–81.
 - 284 Stewart GA. Sequence similarity between a major allergen from the dermatophyte *Trichophyton tonsurans* and exo 1,3-beta-glucanase [letter]. *Clin Exp Allergy* 1993; 23: 154–5.

- 285 Deuell B, Arruda LK, Hayden ML, Chapman MD, Platts-Mills TA. *Trichophyton tonsurans* allergen. I. Characterization of a protein that causes immediate but not delayed hypersensitivity. *J Immunol* 1991; 147:96–101.
- 286 Sward-Nordmo M, Paulsen BS, Wold JK, Wehler T, Jansson PE. Further structural studies of the carbohydrate moiety of the allergen Ag-54 (Cla h II) from the mould *Cladosporium herbarum*. *Carbohydrate Res* 1991; 214:267–79.
- 287 Zhang L, Muradia G, Curran IH, Rode H, Vijay HM. A cDNA clone coding for a novel allergen, Cla h III, of *Cladosporium herbarum* identified as a ribosomal P2 protein. *J Immunol* 1995; 154:710–7.