Gene	*Species*	*PIR Database*		*SwissProt*	*GenEMBL*	*DDBJ*		
CYP2C8	hum	A29782	S06306	P10632	J02832	J03472	J05326	M17397
		E28951	C28951		M17398	M21941	X51535	X54807
		S12688	A38462		X54808	M21942	X65962	Y00498
		S21423	S16902					
		S15075*						
CYP2C9	hum	A28530	S06863	P11712	D00173	J02832	J05326	M21940
		C38462	B38462		M61855	M61857	L16877 →	L16883
		A28951*	B28951*		S46963			
		PX0013*	A41506					
		A48390	B48390					
		B61265						
CYP2C10X	hum	D28951	A27541	P11713	J02832	M15331	M21939	
		A61265*						
CYP2C9 or 10		S26634*	S23777*					
		S39377*						
CYP2C11	rat	A29421	A26685	P08683	J02657	M18356 →	M18363	S68251
		A60782	A60783		X79081			
		S26818	S44310*					
CYP2C12	rat	A32140	A34258	P11510	J03786	M33544 →	M33550	M33656
		B60783	S26819					
		B41425*						
CYP2C13	rat	A32470	A36122	P20814	J02861	J05352	M32277	M33994
		S15586	S26820*	P22693	M81311	M82846	M82848 →	M82855
					X79810			
CYP2C14	rab	A26921		P17666	D00190	D00191		
CYP2C15	rab	B27718		P11372	M19234			
CYP2C16	rab	S12765	A27479*	P15123	M18376	M29968	X13853*	M29661
CYP2C17X	hum	G38462		P33259	M61858	L07093		
CYP2C18	hum	D38462	E38462	P33260	J05326	M61853	M61856	X63904
		A61269	S45369*		L16869 →	L16876	M61858	
					X56452	S63419	S63421	S63424
					S63426			
CYP2C19	hum	F38462	S38753*	P33261	J05326	M61854	M61858	
					L31506	L31507	L32982	L32983
CYP2C20	mon	S28166	A60466*	P33262	S53046			
CYP2C21	dog	A37222						
CYP2C22	rat	A39257	S11160	P19225	M58041	X53477		
CYP2C23	rat	S13101	S29817*	P24470	X55446	U04733	S67064	
CYP2C24	rat	JH0451	PT0435	P33273	M86677	M86678	S59647	S59648
					S59652			
CYP2C25	ham				X63022			
CYP2C26	ham			P33263	D11435			
CYP2C27	ham			P33264	D11436			
CYP2C28	ham			P33265	D11437			
Cyp2c29	mou	A61268*			D17674			
CYP2C30	rab				D26153			
CYP2C31	goa	JC2199	S39314*		X76502			
CYP2C32	pig				U35733			
CYP2C33	pig				U35837	U35838	U35839	
CYP2C34	pig				U35840	U35841	U35842	U35843
CYP2C35	pig				U35844			
CYP2C36	pig				U35845			
CYP2C37	mon							
CYP2C	rat	B60822*						
CYP2C	dog	A60465*						

Gene	*Species*	*PIR Database*		*SwissProt*	*GenEMBL*	*DDBJ*		
CYP2C	hor	PN0659*						
Cyp2c	mou	A23739						
CYP2D1	rat	A31579	A26822	P10633	J02867	M16654	M22328	
		C32970	B32970					
		A30495*	S39761*					
CYP2D2	rat	C31579	B26822	P10634	M16655	M22330	X52027	X52455
		D32970	S16871					
CYP2D3	rat	E32970	S16872	P12938	J02868	X52028	X52456	
CYP2D4	rat	D31579	S16873	P13108	M22331	X52029	X52457	
CYP2D5	rat	B31579	S09611	P12939	J02869	M22329	M25143	X52030
		A32970	S16874		X52458			
CYP2D6	hum	A28883	S01199	P10635	M19697	M20403	M33388	M24499
		A30335	A33629		X07618 →	X07620	X08006	M33189
					X16865 →	X16867	Y00300	A20907
CYP2D7P1	hum				M33387			
CYP2D7P2	hum				X58467			
CYP2D8P1	hum				M33387			
CYP2D8P2	hum				X58468			
Cyp2d9	mou	A27384	B30247	P11714	M23998	M23997	M24262	M24267
		S15806	B27384		J04471			
Cyp2d10	mou	A30247	S15807	P24456	M27167	M27168	M24263	M24265
		S19168		M24268	J04471			
Cyp2d11	mou	S15808	S19169	P24457	M24264	M24266	J04471	
Cyp2d12	mou							
Cyp2d13	mou							
CYP2D14	bov	S29295	S37284	Q01361	X68013	X68481	S45538	
		S29862						
CYP2D15	dog				D17397			
CYP2D16	gpi							
CYP2D17	mon							
CYP2D18	rat							
CYP2D19	mar							
CYP2D20	ham							
CYP2D21	mip							
CYP2D	rat	A28702*						
CYP2E1	hum	A31949	B25341	P05181	D10014	J02625	J02843	M77918
		A29660*	A60554*					
	mon	S28167		P33266	S55205			
	rat	A28145	A25341	P05182	J02627	M20131	S48325	
		S09072*	B27425*					
	rab	A26579	C27718	P08682	M15061	M18770	M19235	M21364
		A27750	A27680*		M21365	M21366		
	ham	S27176*			D17449			
	mar							
Cyp2e1	mou	S18037	S19657	Q05421	X62595	L11650		
		A21231*						
CYP2E2	rab	B27750	B27680*		M18771	M21349 →	M21351	J03726
					M21358 →	M21372	M19162	M19163
CYP2F1	hum	A36036	B36036	P24903	J02906			
Cyp2f2	mou	A39302		P33267	J05349	M77497		
CYP2G1	rat	A33875	A35551	P10610	J04715	M31923 →	M31931	M33296
					M34444			
	rab	S13907	B31944*	P24461				
CYP2H1	chi	A24814	D44107*	P05180	M13454			

Gene	Species	PIR Database		SwissProt	GenEMBL	DDBJ		
CYP2H2	chi	A31418	S10683*	P20678	M25469			
		E44107*						
CYP2J1	rab	A40938			D90405			
CYP2J2	hum							
CYP2J3	rat							
CYP2J3P1	rat							
CYP2J3P2	rat							
CYP2K1	tro	S45644			L11528			
CYP2K2	Fhe							
CYP2L1	lob							
CYP2M1	tro				U16657			
CYP2N1	Fhe							
CYP2P1	Fhe							
CYP2P2	Fhe							
CYP2P3	Fhe							
CYP2Q	Xla				D50560			
CYP2(EST)	Cel				M89049			
CYP3A1	rat	A22631	PX0035*	P04800	M10161	X64401	X62086	D13912
		JX0334	S27107*		D29967	L24207	M28452	
		S21697	S36137*					
		S30378*	S39797					
CYP3A2	rat	A25222	PX0032*	P05183	M13646	X62087	X79319	X79320
		PX0034*	S27108*		U09725 →	U09734	U09742	M74443
		S30379*	S46938		S45634			
CYP3A1 or 3A2		B26997*	A26997*		M86850			
		C26997*						
CYP3A3	hum	A25170*	A29410	P05184	D00003	M13785	N00003	X12387
		A25450						
CYP3A4	hum	A25517	A29815	P08684	M14096	M18907	X12387	D11131
		A32199*	S16900		J04449			
		S03851						
CYP3A3 or 3A4		PX0012*						
CYP3A5	hum	S06491	A34101	P20815	J04813	S74699	S74700	
		A60558*						
CYP3A5P1	hum				L26985			
CYP3A5P2	hum				X90579			
CYP3A6	rab	A29487	A34236	P11707	J05034	M19139		
CYP3A7	hum	S04985	S02152*	P24462	D00408			
		JX0062	PX0014*					
CYP3A8	mon	S04509*	S28168	P33268	S53047			
		S36875*		P25231*				
CYP3A9	rat							
CYP3A10	ham	A40843			M73992			
Cyp3a11	mou	S22334	A60564*		X60452			
CYP3A12	dog	S14275	S04341*	P24463	X54915			
Cyp3a13	mou	S18155			X63023			
CYP3a14	gpi				D16363	D49731		
CYP3A15	gpi				D26487			
Cyp3a16	mou				D26137			
CYP3A17	gpi				D28515			
CYP3A18	rat				X79991	D38381		
CYP3A19	goa				X76503			
CYP3A20	gpi							
CYP3A21	mar							
CYP3A22	mip							
CYP3A	rat	PX0033*						

Gene	*Species*	*PIR Database*		*SwissProt*	*GenEMBL*	*DDBJ*		
CYP3A	she	A60728*						
CYP3A	bab	S21176*	PC2254*	P80056*				
CYP4A1	rat	A26137	B32965	P08516	M14972	M33937	M57718	X07259
		S01336	S21711*					
CYP4A2	rat	A32965		P20816	M33938	M57719		
CYP4A3	rat	A27700*	A32966	P20817	M33936			
CYP4A2 or 4A3		A26380*	S09074*					
CYP4A4	rab	A29368	S32315	P10611	J02818	L04758		
		S32423*	JN0089*					
CYP4A5	rab	A34260	S14761	P14579	M28655	X57209		
CYP4A6	rab	B34260	A34160	P14580	M28656	M29531	L04755	
		S23949	PQ0047*					
CYP4A7	rab	C34260	B34160	P14581	J05150	M29530	M28657	
		JN0090*						
CYP4A8	rat	S08300*	A36304	P24464	M37828			
CYP4A9	hum							
Cyp4a10	mou	S35608*			X69296	X71478		
CYP4A11	hum	S29845	S35609		L04751	X71480	S67580	D26481
		JX0331			D13705	S67581		
Cyp4a12	mou	S35610			X71479			
CYP4A13	gpi	S32714	S35611		X71481			
Cyp4a14	mou							
CYP4A	rab	PQ0048*						
CYP4B1	hum	A33414	S07765	P13584	J02871	X16699		
		S17971						
	rat	PQ0092*	B40164	P15129	M29853			
	rab	A40164		P15128	M29852			
Cyp4b1	mou							
CYP4C1	Bld	A39381		P29981	M63798			
CYP4C2	Aal	PC2257			L38678			
Cyp4c3	Dme							
CYP4C4	Dpu							
CYP4C5	Dpu							
CYP4C6	Dpu							
Cyp4d1	Dme	S25707		P33269	X67645			
Cyp4d2	Dme	S41192			Z23005	X75955		
CYP4D3	Mdo							
CYP4D4	Mdo							
CYP4D5	Aal	PC2270			L38679			
CYP4D6	Aal	PC2271			L38680			
CYP4D7	Aal	PC2272			L38681			
Cyp4d8	Dme							
CYP4D9	Mdo							
Cyp4e1	Dme				K00045			
Cyp4e2	Dme							
Cyp4e3	Dme							
Cyp4e4	Dme							
CYP4F1	rat	S29723		P33274	M94548	S53039		
CYP4F2	hum				U02388	D26480		
CYP4F3	hum	A46661		Q08477	D12620	D12621	S63604	
Cyp4g1	Dme							
CYP4G2	Mdo							
CYP4G3	Mdo							
CYP4H1	Aal	PC2261			L38682			
CYP4H2	Aal	PC2262			L38683			
CYP4H3	Aal	PC2263			L38684			
CYP4H4	Aal	PC2264			L38685			

Gene	Species	PIR Database		SwissProt	GenEMBL	DDBJ		
CYP4H5	Aal	PC2265			L38686			
CYP4H6	Aal	PC2266			L38687			
CYP4H7	Aal	PC2267			L38688			
CYP4H8	Aal	PC2268			L38689			
CYP4H9	Aal	PC2269			L38690			
CYP4J1	Aal	PC2258			L38691			
CYP4J2	Aal	PC2259			L38692			
CYP4J3	Aal	PC2260			L38693			
CYP4K1	Aal	PC2273			L38694			
CYP4L1	Mse				L38668			
CYP4L2	Mse				L38669			
CYP4M1	Mse				L38670			
CYP4M2	Mse				L38671			
CYP4M3	Mse				L38672			
CYP4N1	Mdo							
CYP4N2	Mdo							
Cyp4p1	Dme							
CYP4(EST)	Cel				M89401			
CYP4(EST)	Cel				M80176			
CYP5A1	hum	JQ1143	S10750	P24557	M80646	M80647	S70152	S51388
		A41766	JN0074		D34614 →	D34625	M74055	
CYP5A1	rat				D28773	S69335		
CYP5A1	pig				L13128			
Cyp5a1	mou	JN0683		P36423	L18868			
CYP6A1	Mdo	A32157		P13527	M25367	L27241	L27242	
Cyp6a2	Dme	A45378	A47198	P33270	M88009	S51248	S36482	S36608
CYP6A3	Mdo				U09231			
CYP6A4	Mdo				U09232			
CYP6A5	Mdo				U09343			
CYP6A6	Mdo				U09344			
CYP6A7	Mdo							
Cyp6a8	Dme							
Cyp6a9	Dme							
CYP6B1	Ppx	A46367		Q04552	M80828	M83117	S48952	Z29624
				Q04553	U05037			
CYP6B2	Har				U18085			
CYP6B3	Ppx				U25819			
CYP6B4	Pgl							
CYP6C1	Mdo				U09233			
CYP6C2	Mdo				U09345			
CYP6D1	Mdo				U15168			
CYP7A	hum	S11051	JH0659	P22680	X56088	M89803	M93133	L07951
		S29818	A42201*		L04629 →	L04634	L20569	L20570
					L13460			
	rat	S06632	A38736	P18125	J05460	J05509	M59184 →	M59189
		A36450	A35376		J02926	J05430	X17595	Z14108
		A37071	A35609*		U01962			
		S27206*						
	rab				S67315	L10754		
	ham				L04690			
Cyp7a	mou				L23754			
Cyp7b	mou				U36993			
CYP7B	rat				U36992			
CYP7B	hum							
CYP8	bov				D30718	L34208	S67757	
CYP8	hum				D38145			
CYP9A1	Hvi				U23506			

Gene	*Species*	*PIR Database*		*SwissProt*	*GenEMBL*	*DDBJ*		
Cyp9b1	Dme							
Cyp9b2	Dme							
Cyp9b3	Dme							
CYP10	Lst	JX0225			S46130			
CYP11A1	hum	A25922	S08081*	P05108	D00161 →	D00169	M14565	M28253
		S16069*	S16716		M60421	X05367 →	X05374	
		A48733			X14257*	X58981		
	rat	A27321	A34164	P14137	J05156	M22615	M63125 →	M63133
		A23688						
	bov	A00189	A24067	P00189	J05245	K02130	M25920	
		A28860*	S04947					
		S15865*	A42033*					
		S29644*						
	rab	A49189			S59219			
	pig	A30825	S03188	P10612	X13768	L34259		
		PN0018						
	she				D50057			
	goa				D50058			
	chi	S11144						
	tro	S32197		Q07217	S57305			
CYP11B1	hum	A34181	S11338	P15538	J02985	M24667	X55764	X55765
		S29068*			D16155	D10169	D90428	M32863
					M32878	M32879	J05140	
	rat	B34281*	S05666	P15393	X15431	S58849	S58858	D10107
		A46039	A46040		D14086 →	D14091	S58847	D11354
		B46040	JX0251		S63899			
	bov	A28415	B28860*	P15150	D00185	D00186	D00361	
		JX0050	JX0071		D00449 →	D00457	J02985	M17843
		S15805	A38819		M17844	M36535		
		JX0151						
	she				L34337	L28716		
Cyp11b1	mou	B41552	A41552	P15539	J04451			
		A32210*						
CYP11B2	hum	A37088	B34181	P19099	X54741	M32864	M32880	M32881
					J05140	D90429	D10170	
	rat	A35342	B35342	P30099	D00567	D00568	X52766	S58850
		S09736	A34281*	P30100	S58859	D14092 →	D14097	S58847
		JX0252	JN0615		S64136	U14908	S63898	
		B46039						
	bov							
	ham				S73810			
	Rca				D10984			
Cyp11b2	mou	A41552			S85260			
CYP11B3	rat	JX0253			S59144	D14098 →	D14103	U14907
CYP11B4	bov	same coding seq. as *CYP11B1*, different flanking regions						
CYP11B5P	bov	JU0316						
CYP11B6P	bov	JU0317						
CYP11B7P	bov	JU0318			D00458	D00459		
CYP11B8P	rat				D14104 →	D14108		
Cyp12	Dme							
CYP13A1	Cel				Z48717			
CYP13A2	Cel				Z48717			
CYP13A3	Cel				Z48717			
CYP13A4	Cel				Z48717			
CYP13A5	Cel				Z48717			
CYP13A6	Cel				Z48717			

Gene	*Species*	*PIR Database*		*SwissProt*	*GenEMBL*	*DDBJ*		
CYP13A7	Cel				Z48717			
CYP13A8	Cel				Z48717			
CYP13A9P	Cel				Z48717			
CYP13A10	Cel				Z46934			
CYP14A1	Cel				Z50742			
CYP14A2	Cel				Z50742			
CYP14A3	Cel				Z50742			
CYP14A4	Cel				Z50742			
CYP16A1	Cel				Z54269			
CYP17	hum	A29587	A26366	P05093	M14564	M19489	M63871	S85459
		A40908	S16717		M31146 →	M31153	Z19875	Z20209
		A40921						
	rat	A27659	A30828	P11715	M21208	M22204	M27282	M31681
		A33980	S16719		X14086	Z11902	S40343	S50146
		S20655*	A31359		X69816			
		S24316*	D41425*					
	gpi	D28860*						
	bov	S04346	A26289	P05185	M12547	M64646		
	she				L40335			
	tro	S21125		P30437	S50356	X65800		
	dgf							
	pig	B26366	S22339	P19100	M63507	Z11854 →	Z11856	
		S24233	S30074		S87722	S40340 →	S40342	
	chi	JT0318		P12394	M21406			
Cyp17	mou	A39072	P27786	M64863	S41708			
CYP18	dro							
CYP19	hum	S03962	A31255	P11511	J04127	J05105	M28420	S52034
		A31580	A29480		M30795 →	M30804	M74714	X55983
		A23546*	A34451		Y07508	M18856	X13589	S52789
		A24344*	D24344*		S52793	S52794	D14473	S59092
		B24344*	E24344*		S59095	S59171	M22246	S71536
		C24344*	S22908		M32245	L21982	S85356	D13391
		A40142	A40542*		D29757	S96437	D21240	D21241
		PC2041*						
	rat	A36121	S16901	P22443	M33986	S59505	Z11815	
	bov	S44210			S66248	Z32741	Z32813	
					U18447			
	pig				L15471			
	chi	A31916	A41063	P19098	J04047	M73277 →	M73303	
	jqu				S46949			
	tro							
	cha							
	gol							
Cyp19	mou	S13912		P28649	D00659	D14473		
CYP21A1	bov	A00192	A24101	P00191	K01333	M11267	M12918	M13461
		A27555	A21181		M13545	M25921		
		C28860						
	pig	A32525	S28169	P15540	M83939	S53049		
				Q02390				
	she	A43349	B43349		M92836	M92837	S42095 →	S42097
Cyp21	mou	A00193	A26660	P03940	K03234	M64933	M73820	M15009
CYP21P	hum			P08686	M12793	M12792	M26857	X05445
					M25813	M13935	M13936	S60612
					X58908			

Gene	*Species*	*PIR Database*		*SwissProt*	*GenEMBL*	*DDBJ*		
CYP21	hum	A00191	A27865	P04033	K02771	M12792	M25813	M17252
		A29406	A25446		M26856	X05448	M28548	X05449
		A21889*	A32715		S60612	M23280	M19711	M21544
		S26484	S26485*		M21545	M21547 →	M21550	M23224
		S29670	S29671		M23225	M31022	M31023	X54940
		S29673	S26584		X58898 →	X58908		
Cyp21ps	mou				K03234	M15008		
CYP24	rat	S13918			L04608 →	L04619	S52625 →	S52636
					U03112	D17792		
					X59506	Z28351		
	hum				L13286	S67623		
CYP27	hum	A39740		Q02318	M62401	X59812		
	rat	A36239	A34558	P17178	M38566	Y07534	M73231	
		A33406*	S09198					
	rab	A30293*	A33813	P17177	J04717			
		A32279*	A90152*					
		A90155*						
CYP51	rat	JC2334			D29962	U17697	D55681	
	hum				U23942	D55653		
	Sce	A25563*	A27491	P10614	M15663	M21483	M21484	M18109
		B31569			U10555	T17568		
	Uma				Z48164			
	Spo				Z54096			
	Ctr	A26828*	A31854	P14263	M17595	M23673		
	Cal	S02713		P10613	X13296			
	Cgl				S75389			
	Pit				Z49750			
	Ior				S75391			
	Tae							
CYP51P1	hum							
CYP51P2	hum							
CYP52A1	Ctr	A29297	JS0203	P10615	M15945	M24894	M63258	
CYP52A2	Ctr	S06148	JT0980	P30607	M63258	X17560		
CYP52A3	Cma	JQ1040	S08667	P16496	D00481	M27081	X51931	S77461
		JU0095	A33254	P24458	D01168	D12475		
		JQ1039		P30610				
				P20017				
CYP52A4	Cma	S08668	B40576	P16141	X51932	X55881	D12715	S64322
CYP52A5	Cma	A40576			X55881	D12714		
CYP52A6	Ctr	S22972		P30608	Z13010			
CYP52A7	Ctr	S22973		P30609	Z13011			
CYP52A8	Ctr	S22974		P30610	Z13012			
CYP52A9	Cma	JS0723			D12717	D26160		
CYP52A10	Cma	JS0725			D12719			
CYP52A11	Cma	JS0726			D12719	D26159		
CYP52B1	Ctr	S22975		P30611	Z13013			
CYP52C1	Ctr	S22976		P30612	Z13014			
CYP52C2	Cma	JS0724			D12718			
CYP52D1	Cma	JS0722			D12716			
CYP52E1	Cap	S38894			X76225			
CYP52E2	Cap				X87640			
CYP53	Ani	S10453	S12015	P17549	X52521			
CYP54	Ncr	S09643*			X15033			
CYP55A1	Fox	A40401		P23295	M63340	D14517		
CYP55A2	Cto							
CYP55A3	Cto							

Gene	*Species*	*PIR Database*		*SwissProt*	*GenEMBL*	*DDBJ*		
CYP56	Sce	B36395	S14228	P21595	X55713			
		S13502						
CYP57A1v1	Nha	S45583			L20976			
CYP57A2	Nha				X73145			
CYP58	Fsp				U22462			
CYP59	Eni				L27825			
CYP60A1	Apa				L40839			
CYP60A2	Ani							
CYP60B1	Ani							
CYP61	*Sce*				*Z49211*			
CYP62	Ani							
CYP71A1	Pam	A35867	A44973*	P24465	M32885			
CYP71A2	Sme	S36806		P37118	D14990	X71654		
CYP71A3	Sme	S36807		P37119	X70982			
CYP71A4	Sme	S36805		P37117	X70981			
CYP71A5	Nra							
CYP71A6	Nra							
CYP71A7	Cro				X69779			
CYP71A8	Mpi				Z33875			
CYP71B1	Tar				L24438			
CYP71B2	Ath				Z18072			
CYP71B3	Ath							
CYP71B4	Ath							
CYP71B5	Ath							
CYP71B6	Ath							
CYP71C1	Zma				X81827	X81828		
CYP71C2	Zma				X81829			
CYP71C3	Zma				X81830			
CYP71C3v2	Zma							
CYP71C4	Zma				X81831			
CYP71C5	Zma							
CYP71D1	Cro							
CYP71D2	Cro							
CYP71D3	Ath				Z27299			
CYP72	Cro			Q05047	L10081	X69775	X69789	X69790
					L19074	L19075		
CYP72	Ath				T13009			
CYP73A1	Htu	S28495	A47454	Q04468	Z17369			
CYP73A2	Pau	JC1458	PC1238*		L07634			
CYP73A3	Msa	S36878			L11046			
CYP73A4	Cro				X69788	Z32563		
CYP73A5	Ath				T04086			
CYP73A6	Zma							
CYP73A7	Zma							
CYP73A8	Zma							
CYP73A9	Psa							
CYP73	Pvu	S34739*						
CYP74	Lus				U00428			
CYP74	Par				X78166			
CYP74	Ath				T20864			
CYP75A1	Phy	S32110	S33521		X71130	Z22545	D14588	
		S38985						
CYP75A2	Sme	S43342		P37120	X70824			
CYP75A3	Phy	S33515	S38984		Z22544			
CYP76A1	Sme	S38535		P37121	X71658			
CYP76A2	Sme	S38534		P37122	X71657			

Gene	*Species*	*PIR Database*		*SwissProt*	*GenEMBL*	*DDBJ*		
CYP76B1	Htu							
CYP76C1	Ath							
CYP77A1	Sme	S41599	S40267	P37123	X71656			
CYP77A2	Sme	S41598	S40266	P37124	X71655			
CYP78A1	Zma				L23209			
CYP78A2	Pha				U34744			
CYP79	Sbi				U32624			
CYP80	Bst				U09610			
CYP81A1	Zma							
CYP81A2	Zma							
CYP81A3	Zma							
CYP81A4	Zma							
CYP81B1	Htu							
CYP82	Psa							
CYP83A1	Ath				U18929			
CYP83B1	Ath							
CYP84	Ath							
CYP85	Les							
CYP86A1	Ath							
CYP86A2	Ath				T04172			
CYP87	Han							
CYP88	Zma							
CYP89	Vsa							
CYP90	Ath				X87367	X87368	Z17988*	Z26124*
CYP91A1	Ath							
CYP91A2	Ath							
CYP92A1	Zma							
CYP101	Psp	A00194 C60886*	A25660	P00183	M12546	D00528		
CYP102	Bme	A34286		P14779	J04832			
CYP103	Atu	A32306		P24466	M19352			
CYP104	Atu	B32306		P24467	M19352			
CYP105A1	Sgl	A35401		P18326	M32238	M36480		
CYP105A2	Aau				D26543			
CYP105B1	Sgl	B35401		P18327	M32239	M36481		
CYP105C1	Str	S15809	S19629	P23296	J03356	M31939		
CYP105D1	Stg	S18924 S35901	S24750	P26911	X63601	S45823		
CYP105E1	Rfa	S42052			Z29635			
CYP106A1	Bme	S07764	S17973	P14762	X16610			
CYP106A2	Bme	S32216	S39924	Q06069	Z21972			
CYP107A1	Ser	S16745	S18531	Q00441	M54983	X60379		
CYP107B1	Ser	B42606		P33271	M83110			
CYP107C1	Sth				M80346	D30759		
CYP107D1	San				L37200			
CYP107E1	Mgr				D16098			
CYP107F1	Stg				D45916			
CYP107G1	Shy				X86780			
CYP108	Pse	S27653	A42971	P33006	M91440	S39894		
CYP109	Bsu			P27632	M36988	M24523		
CYP110	Ana	C37842		P29980	M38044			
CYP111	Pse				L23310			
CYP112	Bja				L02323	L12971		
CYP113A1	Ser	B40634			L05776	S51613		
CYP113B1	Sfr				U08223			
CYP114	Bja				L12971	L02323		
CYP115P	Bja				L12971	L02323		

Gene	Species	PIR Database	SwissProt	GenEMBL	DDBJ
CYP116	Rho			U17130	
CYP117	Bja			U12678	
CYP118	Mle			L04666	

Species abbreviations:
Aal, Anopheles albimanus (mosquito)
Aau, Amycolata autotrophica
An, Anabaena species (cyanobacteria)
An, Aspergillus nigra
Apa, Aspergillus parasiticus
Ath, Arabidopsis thaliana
Atu, Agrobacterium tumefaciens
bab, baboon (Papio sp.)
Bca, Brassica campestris (field mustard)
Bja, Bradyrhizobium japonicum
Bld, Blaberus discoidalis (cockroach)
Bme, Bacillus megaterium
bov, bovine
Bst, Berberis stolonifera
Bsu, Bacillus subtilis
Cal, Candida albicans
Cap, Candida apicola
Cca, Chaetodon capistratus (butterfly fish)
Cel, Caenorhabditis elegans (nematode worm)
Cgl, Candida glabrata
cha, channel catfish
chi, chicken
Cma, Candida maltosa
Cro, Catharanthus roseus (syn. Vinca rosea, Madagascar periwinkle)
Cto, Cylindrocarpon tonkinense (a denitrifying fungus)
Ctr, Candida tropicalis
dog, dog
dgf, dogfish (a shark)
Dme, Drosophila melanogaster (fruit fly)
Dpu, Diploptera punctata (Pacific beetle roach)
Eni, Emericella nidulans
Fhe, Fundulus heteroclitus (killifish)
Fox, Fusarium oxysporum
Fsp, Fusarium sporotrichioides
goa, goat (Capra hircus)
gol, goldfish
gpi, guinea pig
grm, green monkey
ham, hamster
Han, Helianthus annuus (sunflower)
Har, Helicoverpa armigera (Australian cotton bollworm)
Htu, Helianthus tuberosus (Jerusalem artichoke)
hum, human
jqu, japanese quail
Les, Lycopersicon esculentum (tomato)
lob, spiny lobster
Lst, Lymnea stagnalis (pond snail)
Lus, Linum usitatissimum (flax, isolated from the seed)
ma, marmoset
Mdo, Musca domestica (house fly)
Mgr, Micromosospora griseorubida
mip, miniature pig
Mle, Mycobacterium leprae
mon, monkey
mou, mouse
Mpi, Mentha piperita (a plant)
Msa, Medicago sativa (alfalfa)
Mse, Manduca sexta (tobacco hornworm)
Mto, Microgadus tomcod (fish)
Ncr, Neurospora crassa
Nha, Nectria haematococca
Nra, Nepeta racemosa (catmint or catnip)
Ota, Opsanus tau (toadfish)
Pam, Persea americana (avocado)
Par, Parthenium argentatum (guayule, a desert shrub)
Pau, Phaseolus aureus (mung bean)
Pgl, Papilio glaucus (butterfly)
Pha, Phalaenopsis (orchid)
Phy, Petunia hybrida cv. Blue Star
pig, pig
Pit, Penicillium italicum
Pma, Pagrus major (wild red sea bream, a fish)
Ppl, Pleuronectes platessa (plaice, a fish)
Ppx, Papilio polyxenes (black swallowtail butterfly)
Psa, Pisum sativum (garden pea)
Pse, Pseudomonas species
Psp, Pseudomonas putida
Pvu, Phaseolus vulgaris (kidney bean)
rab, rabbit
rat, rat
Rca, Rana catesbeiana (bullfrog)
Rfa, Rhodococcus fascians
Rh, Rhodococcus species
Rrh, Rhodococcus rhodochrous
San, Streptomyces antibioticus
Sb1, Sorghum bicolor
Sce, Saccharomyces cerevisiae (baker's yeast)
Sc, Stenotomus chrysops (scup, a fish)
Ser, Saccharopolyspora erythraea
Sfr, Streptomyces fradiae
Sgl, Streptomyces griseolus
she, sheep
Sme, Solanum melongena cv. Sinsadoharanasu (eggplant)
Stg, Streptomyces griseus
Sth, Streptomyces thermotolerans
Str, Streptomyces species
Tae, Triticum aestivum (wheat)
Tar, Thlaspi arvense
tro, trout
Vsa, Vicia sativa (spring vetch)
Xla, Xenopus laevis (african clawed frog)
Zma, Zea mays (corn or maize)

*Indicates peptides less than 100 amino acids long (not a comprehensive listing).

Allelic variants

It is well known that outbred species – not only rats and other laboratory animals, but also agricultual livestock and especially humans, indeed any species – can contain multiple alleles of the same gene. A large number of allelic variants ('microheterogeneity') of *CYP* genes have already been identified in the human, cow and rodents. It must be emphasized that mistakes can be made during sequence reading and translation, typographical errors, inclusion of vector DNA, and other cloning artifacts. Propagation of these errors can contribute to an apparent lack of homogeneity of a particular sequence in the DNA and protein databases. Discussions about errors in sequencing or translation, as well as the existence of variant genes (*e.g. CYP75A1v1, CYP75A1v2*) can be found on the World Wide Web site at (http://drnelson.utmem.edu/homepage.html).

The Nomenclature Committee has arbitrarily assigned proteins having ≤ 3% divergence as derived from two alleles of the same gene, unless nontranslated regions are clearly divergent, indicating distinct genes (Nebert *et al.*, 1987). It is possible, however, that two alleles can display two different activities (reviewed in Nelson *et al.*, 1993). We realize that the distance sequenced in the genomic DNA, 5′-ward and 3′-ward from the translated region, will be crucial in distinguishing between a single gene and two or more genes having arisen from duplication or crossing-over events.

Studies of inheritance patterns will provide the clearest evidence for establishing wnether two alleles or two genes exist. The 3% cut-off connotes 15 amino acid differences, or less, among a 500-residue P450 protein. There are several cases, however, in which this arbitrary cut-off does not hold. For example, even though the rat CYP2B1 and CYP2B2 proteins are 97.4% identical, and the mouse CYP2A4 and CYP2A5 proteins differ at only 11 residues (*ca.* 2.2%), in both cases they are known to represent products from two distinct genes and thus are not allelic variants of the same locus. In other cases as well, it has been difficult to distinguish allelic variants from products derived from two distinct genes (Table 3). More rigorous gene mapping and cloning studies will help clarify some of this confusion.

Scope of the nomenclature system

The suggestion has also been made that engineered recombinant fusion proteins and other chimeric forms of P450 be given a standarized nomenclature. At this time we believe that hybrids are unique to each laboratory, that they should be given sensible names, and that this should not be a duty of the Nomenclature Committee. As long as the parent sequences are correctly named and the fusion joints are clearly given, this designation should be a matter for each individual laboratory. For the replacement of one amino acid with another at a particular amino acid position in the protein (starting with the initiation Met as position No. 1), the recommendations by the Human Genetics Nomenclature Committee should be followed. Point mutations are indicated by the CYP protein name, followed by X###Y where X represents the wild-type amino acid at position ### and Y denotes the mutant amino acid. For example, CYP101 R112A (alanine replacing arginine at position 112) and CYP1A1 I462V (valine replacing isoleucine at position 462). Please do not ask the P450 Gene Superfamily Nomenclature Committee to name point mutants or other artificial constructs. An excellent review on genetically engineered cDNAs encoding chimeric P450 proteins has recently appeared (Oguri *et al.*, 1994).

Expressed sequence tags (ESTs)

The number of public cDNA EST sequences in Genbank has recently exceeded 337000 (as of October 12, 1995) of which 80% are human. The majority of human genes are probably represented here now, and the number of human genes not included will be shrinking steadily over time. Search of the EST database for P450 resulted in 1632 documents, or 0.5% of the total EST database! Similar results were found when an exhaustive search of Genbank release 89 was done in June. An exhaustive analysis of these 1632 P450 EST sequences should identify all human P450 families, including any new ones not yet described. Such an analysis is a major undertaking, and it has not yet been done. Because the ESTs are short fragments, assignment to a family cannot always be made, especially when the sequences are from nonmammalian organisms such as *Caenorhabditis elegans*. More information is available about these ESTs on the Web site.

The amazing *CYP13* family of *C. elegans*

C. elegans has an unusual cluster of P450 genes on a single cosmid, T10B9 (Genbank Z48717). This 34881-bp cosmid contains eight P450 genes and one pseudogene. The last gene in the cosmid is partial, suggesting that the cluster could actually extend

further and contain more genes. All the genes, except the second from the 3′ end, are oriented in the same direction. The last two genes point towards one another, with only 180 bp between them. The first gene has nine introns, the second gene has four, and the others have five introns. The distance between genes is small. The five genes in the central cluster are only separated from one another by 306–614 bp. Since the first seven genes all have the same orientation, with short distances between genes, it is tempting to speculate that this cluster might represent a eukaryotic operon governing P450 gene expression (Blumenthal, 1995).

Variations in signature sequence of *CYP* genes

The original signature sequence for P450 proteins, FxxGxxxCxG (where cysteine of the CxG refers to the enzyme active-site cysteine), was found in 202 of the first 205 database entries (*reviewed in* Nelson *et al.*, 1993). In the database there are now several additional variations or exceptions to this signature sequence. These probably reflect the wider selection of organisms and the more unusual substrates used by some of the newly discovered P450s. One example, CYP55 is a nitric oxide reductase that does not use molecular oxygen (Nakahara *et al.*, 1993). Another example, allene oxide synthase (CYP74) operates on a substrate that brings along its own oxygen in the form of a hydroperoxide (Song *et al.*, 1993). Therefore, pressure to maintain an oxygen-binding pocket involving the conserved Thr and surrounding sequences of the I-helix (Peterson & Graham-Lorence, 1995) has been relieved in CYP74.

There has been speculation that *at times* the heme-binding signature sequence might also be affected; for example, the Phe at the beginning of the signature sequence can be replaced by a Trp. In several instances, Ala is substituted for Gly at the end of the signature sequence. Gly is considered to have a structural rather than a functional role in the enzyme. Since 10 examples are known of Ala at the end of the signature region (and these are from insects, filamentous fungi and plants), the Ala methyl group must be tolerated in the 3-dimensional configuration of the protein. No larger side chains, however, have ever been seen. Several of the less common variants are listed:

FSTGRRGCIA	CYP79 (*Sorghum bicolor*)
FGSGRRICIA	GenEMBL Z24511
FGAGPRTCIA	CYP6C2 (House fly)
FGAGPRICIA	CYP6C1 (House Fly)
FGEGPRHCIA	CYP6D1 (House fly)
FGFGDHRCIA	CYP55A1 (*Fusarium oxysporum*)
FGSGRRMCPA	CYP71D3 (*Arabidopsis thaliana*) and *CYP83B1* [confidential]
FGSGRRGCPA	CYP71B6 [confidential]
WGHGARMCLG	CYP10 (Pond snail)
WSVGVRNCIG	CYP60B1 [confidential]
WGAGHNQCLG	CYP8 (bovine)
WGAGHNHCLG	CYP8 (human)
FGMDKRRCIG	CYP1A1 and 1A3 (Trout)
PSVANKQCAG	CYP74 (flax)
PTVENKQCAG	CYP74 (guayule)

Interestingly, there are no prokaryote sequences that deviate from the original FxxGxxxCxG signature sequence.

Nitric oxide synthase (NOS): example of a P450-like activity that arose via convergent evolution

NOS exhibits a P450-like activity, yet careful alignment by computer analysis has shown that NOS is not a member of the P450 gene superfamily. In fact, the C-terminal domain of NOS is in the same superfamily as that of NADPH-P450 oxidoreductase. It has therefore been suggested that the P450-like function of NOS most likely represents an intriguing example of convergent evolution (*reviewed in* Nelson *et al.*, 1993).

P450 World Wide Web sites

The P450 Gene Superfamily Nomenclature Committee is maintaining a World Wide Web site for sequence alignments of the P450s and bibliographic information on new sequences. This site is on David R. Nelson's MacIntosh at the University of Tennessee in Memphis. The URL is http://drnelson.utmem.edu/homepage.html. This site also links to other WWW sites related to P450, such as the site maintained by Kiril Degtiarenko in Trieste, Italy (http://www.icgeb.trieste.it/p450). There is also a new page specifically for human and mouse P450 information in the Genome Database at Johns Hopkins University (Baltimore); this site is maintained by Amy Voltz (http://gdbdoc.gdb.org/~avoltz/450.html).

Closing remarks

We urge everyone to request free advice from the coauthors of this update about assignments for newly determined P450 sequences, so that manuscripts being written will contain the least amount of ambiguity. There have been several instances in the past where this was not done, and the subsequent publication has

caused unnecessary confusion. All unpublished sequences have been, and will continue to be, held in the strictest confidence.

These nomenclature updates have occurred regularly at 2- or 3-year intervals since 1987, and, in each time period the total number of P450 genes has approximately doubled. In this 3-year period we have seen a decreasing number of newly sequenced mammalian genes and an increasing number of other vertebrate, invertebrate, and especially insect, plant and bacterial P450 gene sequences. Since all of the information reported here – and much more – is already present on the World Wide Web, it is debatable whether further updates will need to be published in a scientific journal.

We hope that this unified nomenclature will continue to be useful to the P450 field in general and adopted by all our colleagues. The nomenclature system described herein will be used in all publications by the authors of this report.

Acknowledgements

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