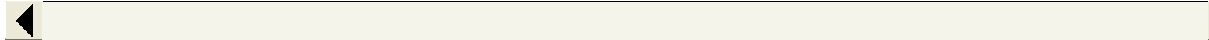# Discrete equilibrium model of chromatography

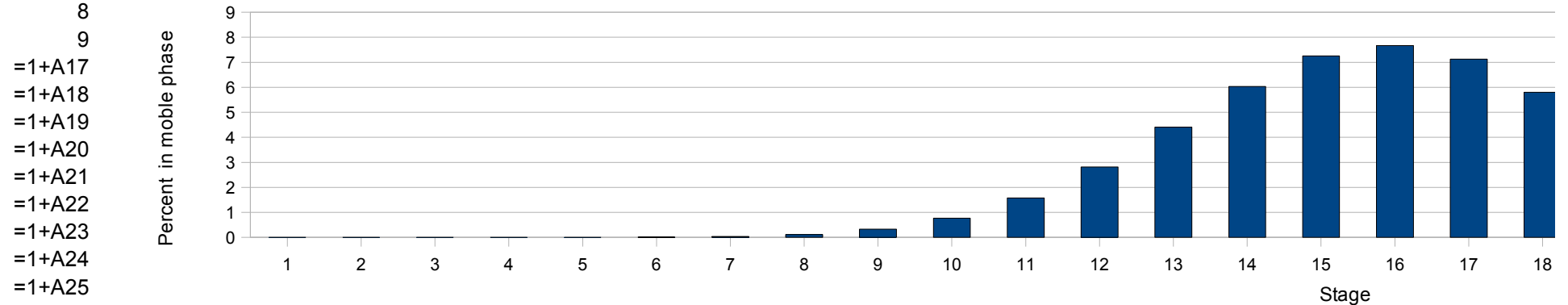## Simulation of a 30-stage Craig countercurrent distribution apparatus

Slider controls the fraction of solute in the mobile phase.

p=fraction				
in mobile phase		k'	inject	
=G4/100		=p/(1+p)	100.00	

Stage		1		2		3		4	
Phase	mobile	stat	mobile	stat	mobile	stat	mobile	stat
1		=E6*p	=E6-p*E6	=C9*p	=C9*(1-p)	=(E9+D8)*p	=(E9+D8)*(1-p)	=G9*p	=G9*(1-p)
2				=B9*p	=B9*(1-p)	=(E10+D9)*p	=(E10+D9)*(1-p)	=(G10+F9)*p	=(G10+F9)*(1-p)
3						=(E11+D10)*p	=(E11+D10)*(1-p)	=(G11+F10)*p	=(G11+F10)*(1-p)
4								=F11*p	=F11*(1-p)
5									
6									
7									
8									
9									
=1+A17									
=1+A18									
=1+A19									
=1+A20									
=1+A21									
=1+A22									
=1+A23									
=1+A24									
=1+A25									
=1+A26									
=1+A27									
=1+A28									
=1+A29									
=1+A30									
=1+A31									
=1+A32									

Graph shows the distribution of solute in the mobile phase of each stage.

=1+A33

5			6			7			8	
mobile	stat		mobile	stat		mobile	stat		mobile	stat
=I9*p	=I9*(1-p)		=K9*p	=K9*(1-p)		=M9*p	=M9*(1-p)		=O9*p	=O9*(1-p)
=(I10+H9)*p	=(I10+H9)*(1-p)		=(K10+J9)*p	=(K10+J9)*(1-p)		=(M10+L9)*p	=(M10+L9)*(1-p)		=(O10+N9)*p	=(O10+N9)*(1-p)
=(I11+H10)*p	=(I11+H10)*(1-p)		=(K11+J10)*p	=(K11+J10)*(1-p)		=(M11+L10)*p	=(M11+L10)*(1-p)		=(O11+N10)*p	=(O11+N10)*(1-p)
=(I12+H11)*p	=(I12+H11)*(1-p)		=(K12+J11)*p	=(K12+J11)*(1-p)		=(M12+L11)*p	=(M12+L11)*(1-p)		=(O12+N11)*p	=(O12+N11)*(1-p)
=H12*p	=H12*(1-p)		=(K13+J12)*p	=(K13+J12)*(1-p)		=(M13+L12)*p	=(M13+L12)*(1-p)		=(O13+N12)*p	=(O13+N12)*(1-p)
			=J13*p	=J13*(1-p)		=(M14+L13)*p	=(M14+L13)*(1-p)		=(O14+N13)*p	=(O14+N13)*(1-p)
						=L14*p	=L14*(1-p)		=(O15+N14)*p	=(O15+N14)*(1-p)
									=N15*p	=N15*(1-p)
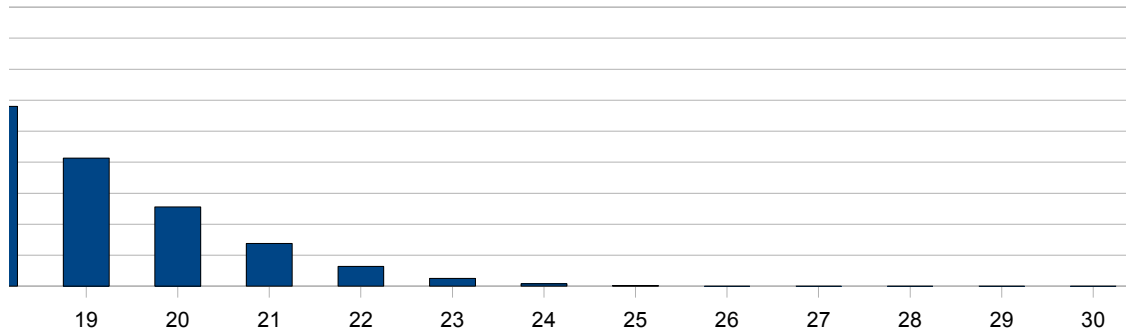
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9		10		11		12	
mobile	stat	mobile	stat	mobile	stat	mobile	stat
=Q9*p	=Q9*(1-p)	=S9*p	=S9*(1-p)	=U9*p	=U9*(1-p)	=W9*p	=W9*(1-p)
=(Q10+P9)*p	=(Q10+P9)*(1-p)	=(S10+R9)*p	=(S10+R9)*(1-p)	=(U10+T9)*p	=(U10+T9)*(1-p)	=(W10+V9)*p	=(W10+V9)*(1-p)
=(Q11+P10)*p	=(Q11+P10)*(1-p)	=(S11+R10)*p	=(S11+R10)*(1-p)	=(U11+T10)*p	=(U11+T10)*(1-p)	=(W11+V10)*p	=(W11+V10)*(1-p)
=(Q12+P11)*p	=(Q12+P11)*(1-p)	=(S12+R11)*p	=(S12+R11)*(1-p)	=(U12+T11)*p	=(U12+T11)*(1-p)	=(W12+V11)*p	=(W12+V11)*(1-p)
=(Q13+P12)*p	=(Q13+P12)*(1-p)	=(S13+R12)*p	=(S13+R12)*(1-p)	=(U13+T12)*p	=(U13+T12)*(1-p)	=(W13+V12)*p	=(W13+V12)*(1-p)
=(Q14+P13)*p	=(Q14+P13)*(1-p)	=(S14+R13)*p	=(S14+R13)*(1-p)	=(U14+T13)*p	=(U14+T13)*(1-p)	=(W14+V13)*p	=(W14+V13)*(1-p)
=(Q15+P14)*p	=(Q15+P14)*(1-p)	=(S15+R14)*p	=(S15+R14)*(1-p)	=(U15+T14)*p	=(U15+T14)*(1-p)	=(W15+V14)*p	=(W15+V14)*(1-p)
=(Q16+P15)*p	=(Q16+P15)*(1-p)	=(S16+R15)*p	=(S16+R15)*(1-p)	=(U16+T15)*p	=(U16+T15)*(1-p)	=(W16+V15)*p	=(W16+V15)*(1-p)
=P16*p	=P16*(1-p)	=(S17+R16)*p	=(S17+R16)*(1-p)	=(U17+T16)*p	=(U17+T16)*(1-p)	=(W17+V16)*p	=(W17+V16)*(1-p)
		=R17*p	=R17*(1-p)	=(U18+T17)*p	=(U18+T17)*(1-p)	=(W18+V17)*p	=(W18+V17)*(1-p)
				=T18*p	=T18*(1-p)	=(W19+V18)*p	=(W19+V18)*(1-p)
						=V19*p	=V19*(1-p)

	13		14		15		16	
	mobile	stat	mobile	stat	mobile	stat	mobile	stat
	=Y9*p	=Y9*(1-p)	=AA9*p	=AA9*(1-p)	=AC9*p	=AC9*(1-p)	=AE9*p	=AE9*(1-p)
	=(Y10+X9)*p	=(Y10+X9)*(1-p)	=(AA10+Z9)*p	=(AA10+Z9)*(1-p)	=(AC10+AB9)*p	###	=(AE10+AD9)*p	###
	=(Y11+X10)*p	=(Y11+X10)*(1-p)	=(AA11+Z10)*p	###	=(AC11+AB10)*p	###	=(AE11+AD10)*p	###
	=(Y12+X11)*p	=(Y12+X11)*(1-p)	=(AA12+Z11)*p	###	=(AC12+AB11)*p	###	=(AE12+AD11)*p	###
	=(Y13+X12)*p	=(Y13+X12)*(1-p)	=(AA13+Z12)*p	###	=(AC13+AB12)*p	###	=(AE13+AD12)*p	###
	=(Y14+X13)*p	=(Y14+X13)*(1-p)	=(AA14+Z13)*p	###	=(AC14+AB13)*p	###	=(AE14+AD13)*p	###
	=(Y15+X14)*p	=(Y15+X14)*(1-p)	=(AA15+Z14)*p	###	=(AC15+AB14)*p	###	=(AE15+AD14)*p	###
	=(Y16+X15)*p	=(Y16+X15)*(1-p)	=(AA16+Z15)*p	###	=(AC16+AB15)*p	###	=(AE16+AD15)*p	###
	=(Y17+X16)*p	=(Y17+X16)*(1-p)	=(AA17+Z16)*p	###	=(AC17+AB16)*p	###	=(AE17+AD16)*p	###
	=(Y18+X17)*p	=(Y18+X17)*(1-p)	=(AA18+Z17)*p	###	=(AC18+AB17)*p	###	=(AE18+AD17)*p	###
	=(Y19+X18)*p	=(Y19+X18)*(1-p)	=(AA19+Z18)*p	###	=(AC19+AB18)*p	###	=(AE19+AD18)*p	###
	=(Y20+X19)*p	=(Y20+X19)*(1-p)	=(AA20+Z19)*p	###	=(AC20+AB19)*p	###	=(AE20+AD19)*p	###
	=X20*p	=X20*(1-p)	=(AA21+Z20)*p	###	=(AC21+AB20)*p	###	=(AE21+AD20)*p	###
			=Z21*p	=Z21*(1-p)	=(AC22+AB21)*p	###	=(AE22+AD21)*p	###
					=AB22*p	=AB22*(1-p)	=(AE23+AD22)*p	###
							=AD23*p	=AD23*(1-p)

17		18		19		20	
mobile	stat	mobile	stat	mobile	stat	mobile	stat
=AG9*p	=AG9*(1-p)	=AI9*p	=AI9*(1-p)	=AK9*p	=AK9*(1-p)	=AM9*p	=AM9*(1-p)
=(AG10+AF9)*p	###	=(AI10+AH9)*p	###	=(AK10+AJ9)*p	###	=(AM10+AL9)*p	###
=(AG11+AF10)*p	###	=(AI11+AH10)*p	###	=(AK11+AJ10)*p	###	=(AM11+AL10)*p	###
=(AG12+AF11)*p	###	=(AI12+AH11)*p	###	=(AK12+AJ11)*p	###	=(AM12+AL11)*p	###
=(AG13+AF12)*p	###	=(AI13+AH12)*p	###	=(AK13+AJ12)*p	###	=(AM13+AL12)*p	###
=(AG14+AF13)*p	###	=(AI14+AH13)*p	###	=(AK14+AJ13)*p	###	=(AM14+AL13)*p	###
=(AG15+AF14)*p	###	=(AI15+AH14)*p	###	=(AK15+AJ14)*p	###	=(AM15+AL14)*p	###
=(AG16+AF15)*p	###	=(AI16+AH15)*p	###	=(AK16+AJ15)*p	###	=(AM16+AL15)*p	###
=(AG17+AF16)*p	###	=(AI17+AH16)*p	###	=(AK17+AJ16)*p	###	=(AM17+AL16)*p	###
=(AG18+AF17)*p	###	=(AI18+AH17)*p	###	=(AK18+AJ17)*p	###	=(AM18+AL17)*p	###
=(AG19+AF18)*p	###	=(AI19+AH18)*p	###	=(AK19+AJ18)*p	###	=(AM19+AL18)*p	###
=(AG20+AF19)*p	###	=(AI20+AH19)*p	###	=(AK20+AJ19)*p	###	=(AM20+AL19)*p	###
=(AG21+AF20)*p	###	=(AI21+AH20)*p	###	=(AK21+AJ20)*p	###	=(AM21+AL20)*p	###
=(AG22+AF21)*p	###	=(AI22+AH21)*p	###	=(AK22+AJ21)*p	###	=(AM22+AL21)*p	###
=(AG23+AF22)*p	###	=(AI23+AH22)*p	###	=(AK23+AJ22)*p	###	=(AM23+AL22)*p	###
=(AG24+AF23)*p	###	=(AI24+AH23)*p	###	=(AK24+AJ23)*p	###	=(AM24+AL23)*p	###
=AF24*p	=AF24*(1-p)	=(AI25+AH24)*p	###	=(AK25+AJ24)*p	###	=(AM25+AL24)*p	###
		=AH25*p	=AH25*(1-p)	=(AK26+AJ25)*p	###	=(AM26+AL25)*p	###
				=AJ26*p	=AJ26*(1-p)	=(AM27+AL26)*p	###
						=AL27*p	=AL27*(1-p)

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	21		22		23		24	
	=AO9*p	=AO9*(1-p)	=AQ9*p	=AQ9*(1-p)	=AS9*p	=AS9*(1-p)	=AU9*p	=AU9*(1-p)
	=(AO10+AN9)*p	###	=(AQ10+AP9)*p	###	=(AS10+AR9)*p	###	=(AU10+AT9)*p	###
	=(AO11+AN10)*p	###	=(AQ11+AP10)*p	###	=(AS11+AR10)*p	###	=(AU11+AT10)*p	###
	=(AO12+AN11)*p	###	=(AQ12+AP11)*p	###	=(AS12+AR11)*p	###	=(AU12+AT11)*p	###
	=(AO13+AN12)*p	###	=(AQ13+AP12)*p	###	=(AS13+AR12)*p	###	=(AU13+AT12)*p	###
	=(AO14+AN13)*p	###	=(AQ14+AP13)*p	###	=(AS14+AR13)*p	###	=(AU14+AT13)*p	###
	=(AO15+AN14)*p	###	=(AQ15+AP14)*p	###	=(AS15+AR14)*p	###	=(AU15+AT14)*p	###
	=(AO16+AN15)*p	###	=(AQ16+AP15)*p	###	=(AS16+AR15)*p	###	=(AU16+AT15)*p	###
	=(AO17+AN16)*p	###	=(AQ17+AP16)*p	###	=(AS17+AR16)*p	###	=(AU17+AT16)*p	###
	=(AO18+AN17)*p	###	=(AQ18+AP17)*p	###	=(AS18+AR17)*p	###	=(AU18+AT17)*p	###
	=(AO19+AN18)*p	###	=(AQ19+AP18)*p	###	=(AS19+AR18)*p	###	=(AU19+AT18)*p	###
	=(AO20+AN19)*p	###	=(AQ20+AP19)*p	###	=(AS20+AR19)*p	###	=(AU20+AT19)*p	###
	=(AO21+AN20)*p	###	=(AQ21+AP20)*p	###	=(AS21+AR20)*p	###	=(AU21+AT20)*p	###
	=(AO22+AN21)*p	###	=(AQ22+AP21)*p	###	=(AS22+AR21)*p	###	=(AU22+AT21)*p	###
	=(AO23+AN22)*p	###	=(AQ23+AP22)*p	###	=(AS23+AR22)*p	###	=(AU23+AT22)*p	###
	=(AO24+AN23)*p	###	=(AQ24+AP23)*p	###	=(AS24+AR23)*p	###	=(AU24+AT23)*p	###
	=(AO25+AN24)*p	###	=(AQ25+AP24)*p	###	=(AS25+AR24)*p	###	=(AU25+AT24)*p	###
	=(AO26+AN25)*p	###	=(AQ26+AP25)*p	###	=(AS26+AR25)*p	###	=(AU26+AT25)*p	###
	=(AO27+AN26)*p	###	=(AQ27+AP26)*p	###	=(AS27+AR26)*p	###	=(AU27+AT26)*p	###
	=(AO28+AN27)*p	###	=(AQ28+AP27)*p	###	=(AS28+AR27)*p	###	=(AU28+AT27)*p	###
	=AN28*p	=AN28*(1-p)	=(AQ29+AP28)*p	###	=(AS29+AR28)*p	###	=(AU29+AT28)*p	###
			=AP29*p	=AP29*(1-p)	=(AS30+AR29)*p	###	=(AU30+AT29)*p	###
					=AR30*p	=AR30*(1-p)	=(AU31+AT30)*p	###
							=AT31*p	=AT31*(1-p)

25		26		27		28	
=(AW9+AV8)*p	###	=(AY9+AX8)*p	=(AY9+AX8)*(1-p)	=(BA9+AZ8)*p	=(BA9+AZ8)*(1-p)	=(BC9+BB8)*p	=(BC9+BB8)*(1-p)
=(AW10+AV9)*p	###	=(AY10+AX9)*p	###	=(BA10+AZ9)*p	###	=(BC10+BB9)*p	###
=(AW11+AV10)*p	###	=(AY11+AX10)*p	###	=(BA11+AZ10)*p	###	=(BC11+BB10)*p	###
=(AW12+AV11)*p	###	=(AY12+AX11)*p	###	=(BA12+AZ11)*p	###	=(BC12+BB11)*p	###
=(AW13+AV12)*p	###	=(AY13+AX12)*p	###	=(BA13+AZ12)*p	###	=(BC13+BB12)*p	###
=(AW14+AV13)*p	###	=(AY14+AX13)*p	###	=(BA14+AZ13)*p	###	=(BC14+BB13)*p	###
=(AW15+AV14)*p	###	=(AY15+AX14)*p	###	=(BA15+AZ14)*p	###	=(BC15+BB14)*p	###
=(AW16+AV15)*p	###	=(AY16+AX15)*p	###	=(BA16+AZ15)*p	###	=(BC16+BB15)*p	###
=(AW17+AV16)*p	###	=(AY17+AX16)*p	###	=(BA17+AZ16)*p	###	=(BC17+BB16)*p	###
=(AW18+AV17)*p	###	=(AY18+AX17)*p	###	=(BA18+AZ17)*p	###	=(BC18+BB17)*p	###
=(AW19+AV18)*p	###	=(AY19+AX18)*p	###	=(BA19+AZ18)*p	###	=(BC19+BB18)*p	###
=(AW20+AV19)*p	###	=(AY20+AX19)*p	###	=(BA20+AZ19)*p	###	=(BC20+BB19)*p	###
=(AW21+AV20)*p	###	=(AY21+AX20)*p	###	=(BA21+AZ20)*p	###	=(BC21+BB20)*p	###
=(AW22+AV21)*p	###	=(AY22+AX21)*p	###	=(BA22+AZ21)*p	###	=(BC22+BB21)*p	###
=(AW23+AV22)*p	###	=(AY23+AX22)*p	###	=(BA23+AZ22)*p	###	=(BC23+BB22)*p	###
=(AW24+AV23)*p	###	=(AY24+AX23)*p	###	=(BA24+AZ23)*p	###	=(BC24+BB23)*p	###
=(AW25+AV24)*p	###	=(AY25+AX24)*p	###	=(BA25+AZ24)*p	###	=(BC25+BB24)*p	###
=(AW26+AV25)*p	###	=(AY26+AX25)*p	###	=(BA26+AZ25)*p	###	=(BC26+BB25)*p	###
=(AW27+AV26)*p	###	=(AY27+AX26)*p	###	=(BA27+AZ26)*p	###	=(BC27+BB26)*p	###
=(AW28+AV27)*p	###	=(AY28+AX27)*p	###	=(BA28+AZ27)*p	###	=(BC28+BB27)*p	###
=(AW29+AV28)*p	###	=(AY29+AX28)*p	###	=(BA29+AZ28)*p	###	=(BC29+BB28)*p	###
=(AW30+AV29)*p	###	=(AY30+AX29)*p	###	=(BA30+AZ29)*p	###	=(BC30+BB29)*p	###
=(AW31+AV30)*p	###	=(AY31+AX30)*p	###	=(BA31+AZ30)*p	###	=(BC31+BB30)*p	###
=(AW32+AV31)*p	###	=(AY32+AX31)*p	###	=(BA32+AZ31)*p	###	=(BC32+BB31)*p	###
=(AW33+AV32)*p	###	=(AY33+AX32)*p	###	=(BA33+AZ32)*p	###	=(BC33+BB32)*p	###

=(AY34+AX33)*p   ###   =(BA34+AZ33)*p   ###   =(BC34+BB33)*p   ###
                                    =(BA35+AZ34)*p   ###   =(BC35+BB34)*p   ###
                                                                       =(BC36+BB35)*p   ###

29		30		31		
=(BE9+BD8)*p	=(BE9+BD8)*(1-p)	=(BG9+BF8)*p	=(BG9+BF8)*(1-p)	=(BI9+BH8)*p	###	1
=(BE10+BD9)*p	###	=(BG10+BF9)*p	###	=(BI10+BH9)*p	###	2
=(BE11+BD10)*p	###	=(BG11+BF10)*p	###	=(BI11+BH10)*p	###	3
=(BE12+BD11)*p	###	=(BG12+BF11)*p	###	=(BI12+BH11)*p	###	4
=(BE13+BD12)*p	###	=(BG13+BF12)*p	###	=(BI13+BH12)*p	###	5
=(BE14+BD13)*p	###	=(BG14+BF13)*p	###	=(BI14+BH13)*p	###	6
=(BE15+BD14)*p	###	=(BG15+BF14)*p	###	=(BI15+BH14)*p	###	7
=(BE16+BD15)*p	###	=(BG16+BF15)*p	###	=(BI16+BH15)*p	###	8
=(BE17+BD16)*p	###	=(BG17+BF16)*p	###	=(BI17+BH16)*p	###	9
=(BE18+BD17)*p	###	=(BG18+BF17)*p	###	=(BI18+BH17)*p	###	10
=(BE19+BD18)*p	###	=(BG19+BF18)*p	###	=(BI19+BH18)*p	###	11
=(BE20+BD19)*p	###	=(BG20+BF19)*p	###	=(BI20+BH19)*p	###	12
=(BE21+BD20)*p	###	=(BG21+BF20)*p	###	=(BI21+BH20)*p	###	13
=(BE22+BD21)*p	###	=(BG22+BF21)*p	###	=(BI22+BH21)*p	###	14
=(BE23+BD22)*p	###	=(BG23+BF22)*p	###	=(BI23+BH22)*p	###	15
=(BE24+BD23)*p	###	=(BG24+BF23)*p	###	=(BI24+BH23)*p	###	16
=(BE25+BD24)*p	###	=(BG25+BF24)*p	###	=(BI25+BH24)*p	###	17
=(BE26+BD25)*p	###	=(BG26+BF25)*p	###	=(BI26+BH25)*p	###	18
=(BE27+BD26)*p	###	=(BG27+BF26)*p	###	=(BI27+BH26)*p	###	19
=(BE28+BD27)*p	###	=(BG28+BF27)*p	###	=(BI28+BH27)*p	###	20
=(BE29+BD28)*p	###	=(BG29+BF28)*p	###	=(BI29+BH28)*p	###	21
=(BE30+BD29)*p	###	=(BG30+BF29)*p	###	=(BI30+BH29)*p	###	22
=(BE31+BD30)*p	###	=(BG31+BF30)*p	###	=(BI31+BH30)*p	###	23
=(BE32+BD31)*p	###	=(BG32+BF31)*p	###	=(BI32+BH31)*p	###	24
=(BE33+BD32)*p	###	=(BG33+BF32)*p	###	=(BI33+BH32)*p	###	25

=(BE34+BD33)*p	###	=(BG34+BF33)*p	###	=(BI34+BH33)*p	###	26
=(BE35+BD34)*p	###	=(BG35+BF34)*p	###	=(BI35+BH34)*p	###	27
=(BE36+BD35)*p	###	=(BG36+BF35)*p	###	=(BI36+BH35)*p	###	28
=(BE37+BD36)*p	###	=(BG37+BF36)*p	###	=(BI37+BH36)*p	###	29
		=(BG38+BF37)*p	###	=(BI38+BH37)*p	###	30
				=(BI39+BH38)*p	###	31