Chi Square Answer sheet for Crosses 1-15
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Table 1: Cross 1: Dihybrid between purple (bluered) male and WT female

Step 3 Analysis

	-	-
RFP	RFP/-	RFP/-
-	-/-	-/-

Red 1/2
Non red 1/2

	-	-
BFP	BFP/-	BFP/-
-	-/-	-/-

Blue 1/2
Non blue 1/2

Grey 1/2 *1/2* 20 = 5
Purple 1/2 *1/2* 20 =5
Blue 1/2 *1/2 *20 =5
Red 1/2 *1/2* 20 =5

Chi Square Table for this clutch:

(1) Phenotype	(2) Observed Number, o	(3) Expected Number, e	(4) $d = (o - e)$	(5) d^2	(6) d^2/e
Grey	2	5	-3	9	1.8
Purple	5	5	0	0	0
Blue	4	5	-1	1	0.2
Red	9	5	4	16	3.2
Total	20	20			3.2

(7) X^2 = the sum of all of the numbers in column 6 = 3.2
(8) Degrees of freedom (df) = n-1 = 3

Conclusion:
(9) P-value and conclusion about your hypothesis: $0.1 < p < 0.5$

Table 2: Cross 2: Monohybrid between red female and red male

	Red	-
Red	R/R	R/-
-	R/-	-/-

Red 3/4 *27 (Total observed number) = 20.25 = 20
Not red 1/4 * 27 = 6.75 = 7

Chi Square Table for this clutch:

(1)	(2)	(3)	(4)	(5)	(6)
Phenotype	Observed Number, o	Expected Number, e	$d = (o - e)$	d^2	d^2/e
Red	25	20	5	25	1.25
Grey	2	7	-5	25	3.57
Total	27	27			4.82

(7) X^2 = the sum of all of the numbers in column 6 = 4.82
(8) Degrees of freedom (df) = n-1 = 1

Conclusion:
(9) P-value and conclusion about your hypothesis:
$$0.03 < P < 0.02$$

Table 3: Cross 3: Monohybrid between red female and WT male

	-	-
Red	R/-	-/-
-	R/-	-/-

Red: 1/2 *24 = 12
Not red: 1/2*24 = 12

Chi Square Table for this clutch:

(1) Phenotype	(2) Observed Number, o	(3) Expected Number, e	(4) d = (o – e)	(5) d^2	(6) d^2/e
Red	14	12	2	4	0.33
Grey	10	12	-2	4	0.33
Total	24	24	0		0.66

(7) X^2 = the sum of all of the numbers in column 6 = 0.66
(8) Degrees of freedom (df) = n-1 = 1

Conclusion:
(9) P-value and conclusion about your hypothesis: 0.4 < P < 0.5

Table 4: Cross 4: Dihybrid between nonstriped, red female and striped, red male

Step 3 analysis

	RFP	RFP
RFP	R/R	R/R
RFP	R/R	R/R

Red: 1

	Stripe	Stripe
Spot	Sp/St	Sp/St
Spot	Sp/St	Sp/St

Stripe: 1

Red/striped 1*1*25 =25

Chi Square Table for this clutch:

(1)	(2)	(3)	(4)	(5)	(6)
Phenotype	Observed Number, o	Expected Number, e	$d = (o - e)$	d^2	d^2/e
Red/Striped	25	25	0	0	0
Total	25	25		0	0

(7) X^2 = the sum of all of the numbers in column 6 = 0

(8) Degrees of freedom (df) = n-1 = 0

Conclusion:

(9) P-value and conclusion about your hypothesis: Cannot do Chi-square analysis when df=0

Table 5: Cross 5: Dihybrid between red female and yellow male

	-	-	Red : 1/2
RFP	R/-	R/-	Not Red : 1/2
-	-/-	-/-	

	-	-	Yellow 1
YFP	Y/-	Y/-	
YFP	Y/-	Y/-	

Orange: 1/2*1 *19 = 9.5
Yellow 1/2 * 1 *19=9.5

Chi Square Table for this clutch:

(1)	(2)	(3)	(4)	(5)	(6)
Phenotype	Observed Number, o	Expected Number, e	$d = (o - e)$	d^2	d^2/e
Yellow	9	10	1	1	0.1
Orange	10	10	0	0	0
Total	19	19			0.1

(7) X^2 = the sum of all of the numbers in column 6 = 0.1
(8) Degrees of freedom (df) = n-1 = 1

Conclusion:
(9) P-value and conclusion about your hypothesis:

$$0.7 < P < 0.8$$

Table 6: Cross 6: Dihybrid between red female and yellow male

Step 3 Analysis

	-	-
RFP	R/-	R/-
RFP	R/-	R/-

Red : 1

	-	-
YFP	Y/-	Y/-
-	-/-	-/-

Yellow 1/2
Grey 1/2

Orange 1 *1/2* 9 = 4.5
Red   1*1/2*9=4.5

Chi Square Table for this clutch:

(1) Phenotype	(2) Observed Number, o	(3) Expected Number, e	(4) d = (o – e)	(5) d^2	(6) d^2/e
Red	5	5	0	0	0
Orange	4	5	1	0.20	0.04
Total	9	10			0.04

(7) X^2 = the sum of all of the numbers in column 6 = 0.04
(8) Degrees of freedom (df) = n-1 = 1

Conclusion:
(9) P-value and conclusion about your hypothesis: 0.8 < P < 0.9

Table 7: Cross 7: Dihybrid between a purple female and purple male

Step 3 analysis

	PFP	-
PFP	P/P	P/-
-	P/-	-/-

Purple: 3/4
Grey: 1/4

	gol	+
gol	*gol/gol*	*gol*/+
+	*gol*/+	+/+

No pigment: 3/4
Pigment: 1/4

Purple, pigment	3/4* 3/4 * 13 = 7.3125	
Purple, no pigment	3/4*1/4 *13 = 2.4375	
Grey, pigment	1/4* 3/4 *13 = 2.4375	
Grey, no pigment	1/4*1/4 *13 = 0.8125	

Chi Square Table for this clutch:

(1) Phenotype	(2) Observed Number, o	(3) Expected Number, e	(4) d = (o – e)	(5) d^2	(6) d^2/e
Purple, pigment	9	7	2	4	0.57
Grey, pigment	2	1	1	1	1.00
Purple, no pigment	1	2	-1	1	0.50
Grey, no pigment	1	2	-1	1	0.50
Total	13	12			2.57

(7) X^2 = the sum of all of the numbers in column 6 = 2.57
(8) Degrees of freedom (df) = n-1 = 3

Conclusion:
(9) P-value and conclusion about your hypothesis: 0.4 < P < 0.5

Table 8: Cross 8: Trihybrid between red male and purple male

	Red	-
Red	R/R	R/-
-	R/-	-/-

Red: 3/4
Not red: 1/4

	-	-
PFP	P/-	P/-
-	-/-	-/-

Purple: 2/4
Not purple: 2/4

	gol	+
gol	*gol/gol*	*gol/+*
+	*gol/+*	+/+

Pigment: 3/4
No pigment: 1/4

Red purple, pigment   3/4 * 2/4 * 3/4 *17 = 4.78
Red purple, no pigment   3/4 * 2/4 * 1/4 *17 = 1.59
Red not purple, pigment   3/4 * 2/4 * 3/4 *17 = 4.78
Red not purple, no pigment   3/4 * 2/4 * 1/4 *17 = 1.59

Not red, purple, pigment   1/4 * 2/4 * 3/4 *17 = 1.59
Not red, purple, no pigment   1/4 * 2/4 * 1/4 *17 = 0.53
Not red, not purple, pigment   1/4 * 2/4 * 3/4 *17 = 1.59
Not red, not purple, no pigment   1/4 * 2/4 * 1/4 *17 = 0.53

Chi Square Table for this clutch:

(1) Phenotype	(2) Observed Number, o	(3) Expected Number, e	(4) d = (o – e)	(5) d^2	(6) d^2/e
Purple, pigment	2	2	0	0	0
Grey, pigment	1	2	-1	1	0.50
Red, pigment	5	5	0	0	0
Red purple, pigment	3	5	2	4	0.80
Grey, no pigment	2	1	1	1	1.00
Red, no pigment	2	2	0	0	0
Red purple, no pigment	2	2	0	0	0
Purple, no pigment	0	1	-1	1	1.00
Total	17				3.30

(7) X^2 = the sum of all of the numbers in column 6 = 3.30

(8) Degrees of freedom (df) = n-1 = 7
(9) P-value and conclusion about your hypothesis: 0.8 < P < 0.9

Table 9: Cross 9: Dihybrid between WT female and orange male

Step 3 Analysis

	-	-
RFP	R/-	R/-
-	-/-	-/-

Red : 1/2
Not Red : 1/2

	-	-
YFP	Y/-	Y/-
-	-/-	-/-

Yellow 1/2
Not yellow 1/2

Red: 1/2*1/2 = 1/4   *14 =3.5
Orange : 1/2*1/2 = 1/4   *14 =3.5
Yellow 1/2 * 1/2 = 1/4   *14 =3.5
Grey: 1/2*1/2 =1/4   *14 =3.5

Chi Square Table for this clutch:

(1) Phenotype	(2) Observed Number, o	(3) Expected Number, e	(4) $d = (o - e)$	(5) d^2	(6) d^2/e
Grey	1	4	-3	9	2.25
Yellow	5	4	1	1	0.25
Red	5	4	1	1	0.25
Orange	3	4	-1	1	0.25
Total	14	14			3.00

(7) X^2 = the sum of all of the numbers in column 6 = 3.00
(8) Degrees of freedom (df) = n-1 = 3

Conclusion:
(9) P-value and conclusion about your hypothesis: 0.3 < P < 0.4

Table 10: Cross 10: Tetrahybrid between short finned, purple male and long finned, yellow female

PFP	- P/-	- P/-
-	-/-	-/-

Purple: 1/2
Not purple: 1/2

YFP	- YFP/-	- YFP/-
YFP	YFP/-	YFP/-

Yellow 1

	Long	Short
Short	S/L	S/S
Short	S/L	S/S

Long 1/2
Short 1/2

	Stripe	Spot
Spot	Sp/St	Sp/Sp
Spot	Sp/St	Sp/Sp

Stripe 1/2
Spot 1/2

Purple yellow, long fin, stripe   1/2 * 1 * 1/2 *1/2* 4 = 0.5
Purple yellow, long fin, spot   1/2 * 1 * 1/2 *1/2* 4 = 0.5
Purple yellow, short fin, stripe   1/2 * 1 * 1/2 *1/2* 4 = 0.5
Purple yellow, short fin, spot   1/2 * 1 * 1/2 *1/2* 4 = 0.5
Yellow, long fin, stripe   1/2 * 1 * 1/2 *1/2* 4 = 0.5
Yellow, long fin, spot   1/2 * 1 * 1/2 *1/2* 4 = 0.5
Yellow, short fin, stripe   1/2 * 1 * 1/2 *1/2* 4 = 0.5
Yellow, short fin, spot   1/2 * 1 * 1/2 *1/2* 4 = 0.5

(1) Phenotype	(2) Observed Number, o	(3) Expected Number, e	(4) $d = (o - e)$	(5) d^2	(6) d^2/e
Purple yellow, long fin, stripe	0	1	1	1	1
Purple yellow, long fin, spot	1	1	0	0	0
Purple yellow, short fin, stripe	0	1	-1	1	1
Purple yellow, short fin, spot	0	1	-1	1	1
Yellow, long fin, stripe	0	1	-1	1	1
Yellow, long fin, spot	0	1	-1	1	1
Yellow, short fin, stripe	2	1	1	1	1
Yellow, short fin, spot	1	1	0	0	0
Total	4				6

(7) X^2 = the sum of all of the numbers in column 6 = 6
(8) Degrees of freedom (df) = n-1 = 7
(9) P-value and conclusion about your hypothesis: $0.5 < P < 0.6$

Table 11: Cross 11: Dihybrid between orange male and orange female

	RFP	-
RFP	R/R	R/-
-	R/-	-/-

Red : 3/4
Not red : 1/4

	YFP	-
YFP	Y/Y	Y/-
-	Y/-	-/-

Yellow 3/4
Not yellow 1/4

Red/ Yellow   : 3/4 * 3/4 *19 = 10.688
Red/ not yellow   : 3/4 * 1/4 *19 = 3.5625
Not red/ yellow   : 1/4 *3/4 *19 = 3.5625
Not red/ not yellow   : 1/4 * 1/4 *19 =1.1875

Chi Square Table for this clutch:

(1)	(2)	(3)	(4)	(5)	(6)
Phenotype	Observed Number, o	Expected Number, e	$d = (o - e)$	d^2	d^2/e
Orange	6	11	-5	25	2.27
Yellow	5	4	1	1	0.25
Grey	4	1	3	9	9.00
Red	4	4	0	0	0
Total	19				11.52

(7) X^2 = the sum of all of the numbers in column 6 = 11.52
(8) Degrees of freedom (df) = n-1 = 3

Conclusion:
(9) P-value and conclusion about your hypothesis: $P < 0.01$

Table 12: Cross 12: Trihybrid between purple male and purple female

	RFP	-
RFP	RFP/RFP	RFP/-
-	RFP/-	-/-

Red: 3/4
Not Red: 1/4

	BFP	-
BFP	BFP/BFP	BFP/-
-	BFP/-	-/-

Blue: 3/4
Not blue: 1/4

	gol	+
gol	*gol/gol*	*gol*/+
+	*gol*/+	*gol*/+

Pigment: 3/4
No pigment: 1/4

Red blue, no pigment	3/4*3/4*1/4 *15 = 2.109
Red blue, pigment	3/4*3/4*3/4*15 = 6.328
Red not blue, no pigment	3/4*1/4*1/4*15= 0.703
Red not blue, pigment	3/4*1/4*3/4*15= 2.109
Not red blue, no pigment	1/4*3/4*1/4*15= 0.703
Not red blue, pigment	1/4*3/4*3/4*15= 2.109
Not red not blue, no pigment	1/4*1/4*1/4*15= 0.0156
Not red not blue, pigment	1/4*1/4*3/4*15= 0.703

Chi Square Table for this clutch:

(1) Phenotype	(2) Observed Number, o	(3) Expected Number, e	(4) $d = (o - e)$	(5) d^2	(6) d^2/e
Purple, pigment	4	6	-2	4	0.66
Grey, pigment	1	1	0	0	0
Blue, pigment	3	2	1	1	0.50
Red, pigment	6	2	4	16	8
Purple, no pigment	1	2	-1	1	0.50
Grey, no pigment	0	0	0	0	0
Blue, no pigment	0	1	-1	1	1
Red, no pigment	0	1	-1	1	1
Total	15				11.66

(7) X^2 = the sum of all of the numbers in column 6 = 11.66
(8) Degrees of freedom (df) = n-1 =7
(9) P-value and conclusion about your hypothesis: $0.1 < P < 0.15$

Table 13: Cross 13: Trihybrid between red male and yellow female

	-	-	
RFP	RFP/-	RFP/-	Red : 1
RFP	RFP/-	RFP/-	

	-	-	
YFP	YFP/-	YFP/-	Yellow: 1
YFP	YFP/-	YFP/-	

	gol	gol	
+	gol/+	gol/+	Pigment: 1
+	gol/+	gol/+	

Orange, pigment 1* 1* 1* 6 = 6

Chi Square Table for this clutch:

(1)	(2)	(3)	(4)	(5)	(6)
Phenotype	Observed Number, o	Expected Number, e	$d = (o - e)$	d^2	d^2/e
Orange, striped	6	6			
Total	6	6			

(7) X^2 = the sum of all of the numbers in column 6 =
(8) Degrees of freedom (df) = n-1 = 0

Conclusion:
(9) P-value and conclusion about your hypothesis:
Cannot carry out Chi square analysis with 0 degrees of freedom

Table 14: Cross 14: Trihybrid between Green, no pigment male and purple, striped male

	-	-
GFP	GFP/-	GFP/-
-	-/-	-/-

Green : 1/2
Not green: 1/2

	PFP	-
-	PFP/-	-/-
-	PFP/-	-/-

Purple: 1/2
Not purple: 1/2

	gol	*gol*
+	*gol*/+	*gol*/+
+	*gol*/+	*gol*/+

Pigment: 1

Green-purple   ½ * ½ * 1 * 12 = 3
Green, not purple   ½ * ½ * 1 * 12 = 3
Purple, not green   ½ * ½ * 1 * 12 = 3
Note green, not purple   ½ * ½ * 1 * 12 = 3

Chi Square Table for this clutch:

(1) Phenotype	(2) Observed Number, o	(3) Expected Number, e	(4) d = (o – e)	(5) d^2	(6) d^2/e
Green-purple	5	3	2	4	1.33
Green	4	3	1	1	0.33
Purple	2	3	-1	1	0.33
Grey	1	3	-2	4	1.33
Total					3.32

(7) X^2 = the sum of all of the numbers in column 6 = 3.32
(8) Degrees of freedom (df) = n-1 = 3

Conclusion:
(9) P-value and conclusion about your hypothesis: 0.3 < P < 0.4

Table 15: Cross 15: Monohybrid between WT female and red male

	-	-
RFP	R/-	R/-
-	-/-	-/-

Red: 1/2 *12 = 6
Not Red: 1/2 *12 = 6

Chi Square Table for this clutch:

(1)	(2)	(3)	(4)	(5)	(6)
Phenotype	Observed Number, o	Expected Number, e	$d = (o - e)$	d^2	d^2/e
Red	4	6	-2	4	0.66
Grey	8	6	2	4	0.66
Total	12	12			1.32

(7) X^2 = the sum of all of the numbers in column 6 = 1.32
(8) Degrees of freedom (df) = n-1 = 1

Conclusion:
(9) P-value and conclusion about your hypothesis: $0.2 < P < 0.3$

											Chi squared														
											Degrees of freedom (df)														
25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	p value
11.52	10.86	10.20	9.54	8.90	8.26	7.63	7.01	6.41	5.81	5.23	4.66	4.11	3.57	3.05	2.56	2.09	1.65	1.24	0.87	0.55	0.30	0.11	0.02	0.00	.99
16.47	15.66	14.85	14.04	13.24	12.44	11.65	10.86	10.09	9.31	8.55	7.79	7.04	6.30	5.58	4.87	4.17	3.49	2.83	2.20	1.61	1.06	0.58	0.21	0.02	.90
18.94	18.06	17.19	16.31	15.44	14.58	13.72	12.86	12.00	11.15	10.31	9.47	8.63	7.81	6.99	6.18	5.38	4.59	3.82	3.07	2.34	1.65	1.01	0.45	0.06	.80
20.87	19.94	19.02	18.10	17.18	16.27	15.35	14.44	13.53	12.62	11.72	10.82	9.93	9.03	8.15	7.27	6.39	5.53	4.67	3.83	3.00	2.19	1.42	0.71	0.15	.70
22.62	21.65	20.69	19.73	18.77	17.81	16.85	15.89	14.94	13.98	13.03	12.08	11.13	10.18	9.24	8.30	7.36	6.42	5.49	4.57	3.66	2.75	1.87	1.02	0.27	.60
24.34	23.34	22.34	21.34	20.34	19.34	18.34	17.34	16.34	15.34	14.34	13.34	12.34	11.34	10.34	9.34	8.34	7.34	6.35	5.35	4.35	3.36	2.37	1.39	0.45	.50
26.14	25.11	24.07	23.03	21.99	20.95	19.91	18.87	17.82	16.78	15.73	14.69	13.64	12.58	11.53	10.47	9.41	8.35	7.28	6.21	5.13	4.04	2.95	1.83	0.71	.40
28.17	27.10	26.02	24.94	23.86	22.77	21.69	20.60	19.51	18.42	17.32	16.22	15.12	14.01	12.90	11.78	10.66	9.52	8.38	7.23	6.06	4.88	3.66	2.41	1.07	.30
30.68	29.55	28.43	27.30	26.17	25.04	23.90	22.76	21.61	20.47	19.31	18.15	16.98	15.81	14.63	13.44	12.24	11.03	9.80	8.56	7.29	5.99	4.64	3.22	1.64	.20
32.28	31.13	29.98	28.82	27.66	26.50	25.33	24.16	22.98	21.79	20.60	19.41	18.20	16.99	15.77	14.53	13.29	12.03	10.75	9.45	8.12	6.74	5.32	3.79	2.07	.15
34.38	33.20	32.01	30.81	29.62	28.41	27.20	25.99	24.77	23.54	22.31	21.06	19.81	18.55	17.28	15.99	14.68	13.36	12.02	10.64	9.24	7.78	6.25	4.61	2.71	.10
34.90	33.71	32.51	31.31	30.10	28.89	27.67	26.45	25.21	23.98	22.73	21.48	20.21	18.94	17.65	16.35	15.03	13.70	12.34	10.95	9.52	8.04	6.49	4.82	2.87	.09
35.47	34.27	33.06	31.85	30.63	29.41	28.18	26.95	25.71	24.46	23.20	21.93	20.66	19.37	18.07	16.75	15.42	14.07	12.69	11.28	9.84	8.34	6.76	5.05	3.06	.08
36.11	34.89	33.68	32.45	31.22	29.99	28.75	27.50	26.25	24.99	23.72	22.44	21.15	19.85	18.53	17.20	15.85	14.48	13.09	11.66	10.19	8.67	7.06	5.32	3.28	.07
36.82	35.60	34.37	33.13	31.89	30.65	29.40	28.14	26.87	25.59	24.31	23.02	21.71	20.39	19.06	17.71	16.35	14.96	13.54	12.09	10.60	9.04	7.41	5.63	3.54	.06
37.65	36.42	35.17	33.92	32.67	31.41	30.14	28.87	27.59	26.30	25.00	23.68	22.36	21.03	19.68	18.31	16.92	15.51	14.07	12.59	11.07	9.49	7.81	5.99	3.84	.05
38.64	37.39	36.13	34.87	33.60	32.32	31.04	29.75	28.44	27.14	25.82	24.49	23.14	21.79	20.41	19.02	17.61	16.17	14.70	13.20	11.64	10.03	8.31	6.44	4.22	.04
39.88	38.61	37.33	36.05	34.76	33.46	32.16	30.84	29.52	28.19	26.85	25.49	24.12	22.74	21.34	19.92	18.48	17.01	15.51	13.97	12.37	10.71	8.95	7.01	4.71	.03
41.57	40.27	38.97	37.66	36.34	35.02	33.69	32.35	31.00	29.63	28.26	26.87	25.47	24.05	22.62	21.16	19.68	18.17	16.62	15.03	13.39	11.67	9.84	7.82	5.41	.02
44.31	42.98	41.64	40.29	38.93	37.57	36.19	34.81	33.41	32.00	30.58	29.14	27.69	26.22	24.73	23.21	21.67	20.09	18.48	16.81	15.09	13.28	11.34	9.21	6.63	.01
52.62	51.18	49.73	48.27	46.80	45.31	43.82	42.31	40.79	39.25	37.70	36.12	34.53	32.91	31.26	29.59	27.88	26.12	24.32	22.46	20.51	18.47	16.27	13.82	10.83	.001

Note. Problems with df>25 would rarely be worked by hand.