Name: _____ **Date:** _____ **Class:** _____

🐠 GloFish© Genetics: Inheritance of Fluorescent Glow

Background: Traits in living organisms are inherited through genes—specific sections of DNA that carry instructions for building proteins and determining characteristics. Since all living things share the same basic genetic code, genes from one species can sometimes function in another. Thanks to advances in genetic engineering, scientists can now transfer genes between organisms.

One famous example is the GloFish®, a type of zebrafish that glows under black light. This glow comes from a gene originally found in jellyfish, which was inserted into the zebrafish's DNA. Depending on which glow genes are present, GloFish can display different fluorescent colors like red, green, and yellow. These traits can be inherited, much like hair color in humans.

Each color trait is controlled by a gene that acts like a light switch—it can be "on" (dominant) or "off" (recessive). Sometimes, two color genes can both be "on" at the same time, resulting in a blended or combined appearance. This is called **incomplete dominance**. For instance, a fish with both red and yellow dominant genes might appear orange—like mixing paint!

GloFish© are genetically engineered zebrafish that glow under black light. Their glowing traits come from genes taken from jellyfish and other fluorescent organisms. These genes can be passed on from parent to offspring.

Each glow color is controlled by a **gene with two alleles** ("switches").

- If the switch is **on** (dominant), the color appears.
- If the switch is **off** (recessive), no color appears.
- Some combinations of colors show **incomplete dominance**, where two "on" switches from different colors combine (e.g., red + yellow = orange).
- If **all** the switches are **off**, no color appears. This is known as "wildtype".

Let's explore this idea further by considering a hypothetical cross between a red GloFish (with the red gene "on" and yellow gene "off") and a yellow GloFish (with the yellow gene "on" and red gene "off").

Key:

GloR = on gene for red

GloR- = off gene for red

GloY = on gene for yellow

GloY- = off gene for yellow

GloB = on gene for blue

GloB- = off gene for blue

Part 1: Predicting Inheritance with Punnett Squares

Example Cross:

Red Fish: GloR/GloR ; GloY-/GloY-
Yellow Fish: GloR-/GloR- ; GloY/GloY

Step 1: Determine Gametes

Each parent produces gametes with one allele for **each gene**.

Parent 1 (GloR/GloR ; GloY-/GloY-):

- Can only produce **GloR ; GloY-**

Parent 2 (GloR-/GloR- ; GloY/GloY):

- Can only produce **GloR- ; GloY**

Parent 1 → **Parent 2 ↓**	**GloR ; GloY-**	**GloR ; GloY-**	**GloR ; GloY-**	**GloR ; GloY-**
GloR- ; GloY				
GloR- ; GloY				
GloR- ; GloY				
GloR- ; GloY				

What color are all the offspring? _____

Concept Check

1. What would happen if a red fish (GloR/GloR-; GloY-/GloY-) was crossed with a fish that had no dominant glow genes (GloR-/GloR-; GloY-/GloY-)?

Parent 1 (GloR/GloR- ; GloY-/GloY-):

- Can produce **GloR ; GloY-**
- Can produce **GloR- ; GloY-**

Parent 2 (GloR-/GloR- ; GloY-/GloY-):

- Can only produce **GloR- ; GloY-**

Parent 1 → **Parent 2 ↓**	**GloR ; GloY-**	**GloR ; GloY-**	**GloR- ; GloY-**	**GloR- ; GloY-**
GloR- ; GloY-				
GloR- ; GloY-				
GloR- ; GloY-				
GloR- ; GloY-				

What are the colors (phenotypes) of the offspring?

_____

Calculate the phenotype percentages of each color.

_____

2. What if a red fish (GloR/GloR-; GloY-/GloY-) was crossed with an **orange fish** (GloR/GloR-; GloY/GloY-)?

Parent 1 (GloR/GloR- ; GloY-/GloY-):

- Can produce **GloR ; GloY-**
- Can produce **GloR- ; GloY-**

Parent 2 (GloR/GloR- ; GloY/GloY-):

- Can produce **GloR ; GloY**
- Can produce **GloR ; GloY-**
- Can produce **GloR- ; GloY**
- Can produce **GloR- ; GloY-**

Parent 1 → **Parent 2 ↓**	**GloR ; GloY-**	**GloR ; GloY-**	**GloR- ; GloY-**	**GloR- ; GloY-**
GloR ; GloY				
GloR ; GloY-				
GloR- ; GloY				
GloR- ; GloY-				

What are the colors (phenotypes) of the offspring?

_____

Calculate the phenotype percentages of each color.

_____

Part 2: Chi-Squared Analysis

A **blue GloFish** mates with a **wildtype** (grey, no glow). They produce:

- **7 blue offspring**
- **6 grey offspring**

Your Hypothesis: Do you think the blue gene is **dominant** or **recessive** to the wildtype?

Hypothesis:_____

What are the two possible genotypes for the blue GloFish?_____

What would be the only genotype for a wildtype GloFish?_____

Remember that the only way to get a wildtype GloFish is for all switches to be turned off. Use GloB for turned on blue genes and GloB- for turned off blue genes. You can use either color (GloY- or GloR-) for the turned off gene.

What are all possible combinations for each fish?

Blue GloFish _____

Wildtype GloFish _____

Expected Results: Complete the Punnett square for the cross, then determine the expected ratio. Use this to calculate expected numbers of each offspring.

Parent 1 → **Parent 2 ↓**				

Formula for the Chi-square statistic:

$$\chi^2 = \sum \frac{(o-e)^2}{e}$$

Key:

o = observed

e = expected

d = degrees of freedom

Σ = sum

x^2 = Chi-square, the test statistic

Fish Color	**Observed (o)**	**Expected (e)**	**d = o – e**	**d²**	**d² / e**
Blue	7				
Grey	6				
Total	13				

Chi-squared value (X^2): _____

Degrees of freedom (df): _____

P-value (use chi-square chart): _____

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.																									

Conclusion Questions

1. Does your p-value support your hypothesis? Why or why not?

   _____

2. Is the **blue glow gene** dominant or recessive based on your results?

   _____

3. What could be another explanation if your prediction was off?

   _____