Question 1:

Because there are two chromosomes and there's one allele (half the genotype) on each one.

Normal is homozygous CAT CAT
Mutant is heterozygous AAT CAT

Phenotype is clear and red respectively

Red is autosomal dominant

Question 2:

ACG TCA ATC GTA CAT CGC
UGC AGU UAG CAU GUA GCG
ACG UCA AUC GUA CAU CGC
Thr Ser Ile Val His Arg

ACG TCA ATC GTA AAT CGC
UGC AGU UAG CAU UUA GCG
ACG UCA AUC GUA AAU CGC
Thr Ser Ile Val Asn Arg

Missense Single Nucleotide Polymorphism, His -> Asn

Question 3:

>>> you observe higher transcript levels for a gene coding for fish haemoglobin

The sequence increases the transcription level for fish haemoglobin (enhancer sequence) and thus makes the fish appear more red (phenotype) since haemoglobin is red.

It can also enhance the pigment or affect the pathway of expression of colour (different level of gene expression as a result of enhancer sequence).

Question 4:

>>> 4% of the total is codes for the red.

0.04 : 0.96
(0.04 + 0.96)^2 = 1
0.04^2 + 2*0.04*0.96 + 0.96^2 = 1

Homozygous red = 0.04^2 = 0.0016

0.16%

Question 5:
$1-0.96^2 = 0.0784$

7.84% of fish are red. (homozygous red and heterozygous)

Question 6:
>>> when you ask Lily about the current percentage of the fish in her lake that have the red phenotype, she says that it is twice as much as your expectation

Potential reasons
1. Selective advantage in being red - transparent fish are dying and red fish are surviving
2. Red fish are more attractive to mates
3. More haemoglobin leads to higher stamina in fish, allowing them to escape predation and more successfully pass on alleles to offspring

Question 7:
>>> When you compare the corresponding DNA sequence in normal and fast fish you see a nucleotide change (G->T) that is always present in fast fishes. The change is at the boundary between different "sections" of the gene.

The process affected is likely splicing. Since the change is on the boundary between genes, and the bases at the boundary between genes are vital for correct splicing, we can reasonably infer that the change affected/affects how the spliceosome recognizes the boundary and produced/produces another protein as a result (different amino acid sequence).

The *Fast* trait is dominant - having both slow and fast genes produces the fast phenotype.

Question 8:
>>> *Fast* and *Red* are on the same chromosome, with 30% recombination between the two (linked) in different species of fish.

Red = R | T = Transparent | F = Fast | S = Slow

	RF	RF	RF	RF
TS	RFTS	RFTS	RFTS	RFTS
TS	RFTS	RFTS	RFTS	RFTS
TS	RFTS	RFTS	RFTS	RFTS
TS	RFTS	RFTS	RFTS	RFTS

Genotype: RFTS
Phenotype: Red and Fast (dominant, as shown in Q1)

Answer is C

Question 9:

Gametes produced by F1 individuals: RF, RS, TF, TS
Percentages: 35%, 15%, 15%, 35%

(Based on the 30% recombinant chance I took 30% from each RF and TS to produce the new gametes)

Question 10:

	RF	RS	TF	TS
RF	RFRF	RFRS	RFTF	RFTS
RS	RSRF	RSRS	RSTF	RSTS
TF	TFRF	TFRS	TFTF	TFTS
TS	TSRF	TSRS	TSTF	TSTS

Red = Red Fast, Blue = Red Slow, Green = Transparent Fast, Yellow = Transparent Slow
Ratio of phenotypes = 9:3:3:1

Genotypes made: RFRF, RFRS, RFTF, RFTS, RSRS, RSTF, RSTS, TFTF, TFTS, TSTS

Some of them are produced by recombinant gametes (RS, TF)

Question 11:

>>> Only genotypes retrieved are RFRF, RFTS, and TSTS in ratio 1:2:1

Only phenotypes are Red Fast and Transparent Slow - Red Slow and Transparent Fast do not exist, and most fish are Red Fast (75%)

Reasons:

- The RFTS genotype dominates and the Red and Fast alleles are more favoured - the genotypes retrieved are in the ratio if two RFTS fishes mated
- The Transparent and Slow alleles don't face a selection pressure so they aren't forcibly removed but are sexually selected against, and remain only when two heterozygous individuals hit that 25% chance of a TSTS fish.

Question 12:

>>> Dissolved oxygen decreases ~linearly from 10 to 4; fertilizer use increases from 30 kg/acre to 90 kg/acre (both after 2016)

Increased (excessive) use of nutrients trigger algae blooms, leading to more plant matter, leading to blocking out the sun, leading to aquatic plants dying due to lower rates of photosynthesis, leading to more decomposed/dead plant matter, leading to more decomposer action decomposing the plant matter using up the oxygen, leading to less dissolved oxygen in the water, leading to less aerobic respiration by lolfish, leading to individuals that aren't as adapted to this environment dying and thus decreasing the lolfish population.

Question 13:

>>> Red AND Fast fish have 10% more offspring that survive in such environments.

The Red sequence is an enhancer for the haemoglobin gene, so more haemoglobin will be produced by individuals possessing the Red gene and more oxygen can be obtained from the water and thus facilitate sufficient aerobic respiration.

The Red and Fast genes are linked, so it follows that the survivors with Red are often also Fast.

Physiological reason might be that having sufficient O_2 from haemoglobin allows the Fast gene to work as the muscles only work in higher-oxygen environments?

However, the survival might be higher in Red and Slow individuals as being Fast consumes more oxygen, unless faster fish can swim to areas of higher oxygen concentration.

Question 14:

I think D as the Red allele is selected for, but the Fast allele is only linked and not directly influencing the survival.

Transparent and Slow individuals will die off as they're less adapted to this environment and given that they only mate once a year, the chance of T or S allele being propagated decreases every year and the remaining alleles would be R and F. And once again, T is the allele being selected against, which gives the S allele a higher chance of survival since SS individuals won't be selected against and FS heterozygous individuals will persist.

Over a long period of time, T will survive only in heterozygous individuals and their heterozygous offspring.

Therefore, the final stable population will have a higher frequency of R and F alleles but more R than F.

Question 15:

Addressing the economic aspect of this question, the local government should set a cap on the amount of fertilizer used to prevent a Prisoner's dilemma situation facing the farmers (more nutrients = more crops, not fair that the other guy gets to use more).

Then, we can talk about the technical engineering solution. The local government can also create waterways between the lake and the farms to funnel away the contaminated water, or plant more crops there to capitalize on the free nutrients.

That said, she must also consider the livelihoods of the farmers as she's doing this for a population of fishes, but the farmers do this for their livelihoods. Of course, one can argue that the farms have no need to maximize their harvests, to produce as much as they do, but most people are willing to exchange the lives of fishes for money. It is what it is.

Moreover, to mobilize the government to save this population of fishes will raise the obvious question of their economic value and how this use of taxpayer money is beneficial to their society, at which point Lily would have to walk a path of thorns to save the fish. She also has to deal with bureaucracy to ensure that the project is finished before the fish becomes locally extinct. Immense respect to Lily, but she'd be better off relocating the fish or investing in technology to purify the water, with what little budget she has. :(