Pearson Edexcel International Advanced Level

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# Biology

## International Advanced Level

## UNIT 5: Respiration, Internal Environment, Coordination and Gene Technology

**Pre-release Material**

**Scientific article for use with Question 8**

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**Scientific article for use with Question 8**

**Article 1**

1. One species of whitefly, an aphid-like insect, has incorporated a portion of plant DNA into its genome that protects it from leaf toxins. It seems to be the first known example of so-called horizontal gene transfer between a plant and insect in which the transferred genetic material performs a useful function.

2. While sequencing the genome of the silverleaf whitefly (*Bemisia tabaci*), Ted Turlings at the University of Neuchâtel in Switzerland and his colleagues discovered a gene known as *BtPMaT1*, which is found in plants but never previously seen in insects.

3. This gene may have an important function in plants. The plants generate toxins to defend themselves from attack by animals. The team suspects that the *BtPMaT1* gene may help plants store these toxins in a harmless form so the plants don't poison themselves. Similarly, the gene may help the whitefly avoid being poisoned when it eats the plant.

4. Turlings says the gene transfer event occurred between 35 million and 80 million years ago, when the silverleaf whitefly and other whitefly species that lack the gene split from a common ancestor.

5. The gene transfer event may have involved viruses that cause disease in plants and are transmitted via the whiteflies. Some DNA from a plant may have been taken up by a virus, transmitted to the whiteflies and then subsequently assimilated into the insects' genomes.

6. "[Some] viruses basically incorporate their own genome into the cells of their hosts," says Turlings. The research suggests that the extent to which horizontal gene transfer occurs in nature is probably underestimated, says Caitlin Byrt at the Australian National University in Canberra. "What this shows is that where there's a really strong pressure for survival on an organism, it can actually borrow genetic information that helps it do that from other organisms," says Byrt.

7. The researchers demonstrated the function of *BtPMaT1* in whiteflies by selectively interfering with the gene using small molecules of RNA. Disrupting the gene's function made the whiteflies susceptible to compounds known as phenolic glycosides that are present in tomato plants. After feeding on tomato plants that had been genetically modified to produce the RNA molecules, all whiteflies subsequently died.

8. "This demonstrates a mechanism that we could use in engineering crops to basically target plant pests, and target the resistance of crops to plant pests," says Byrt, although she points out that horizontal gene transfer may then allow the pests to evolve resistance to our genetic engineering.

**Article 2**

9. GloFish® are fluorescent transgenic zebrafish. These are illegal in many countries. GloFish® are zebrafish containing a *dsRed* gene from a sea coral that makes the fish fluorescent under ultraviolet light. Zebrafish are normally silver and black. There are several versions of the *dsRed* gene, each resulting in a different coloured phenotype, from fluorescent yellow to fluorescent red.

10. As it is illegal to import these transgenic fish into many countries, technology is used to detect them. A PCR-based method has been developed to detect transgenic zebrafish harbouring the gene (*dsRed*) coding for the red fluorescent protein, originally isolated from the marine sponge *Discosoma striata*.

11. Two types of PCR have been performed:

    - PCR to detect amplifiable genomic zebrafish DNA was checked using primers specific for the zebrafish parvalbumin gene;
    - PCR with primers to specifically amplify the *dsRed* gene.

12. In both PCR systems, genomic DNA isolated from wild type zebrafish was used as a control template, in the second PCR system, the plasmid *dsRed2-N1* was used as a positive control.

13. Applying this method to several specimens of presumed GloFish® from traders in the Netherlands and Germany revealed the presence of transgenic fish. In addition, a rapid method for screening zebrafish suspected to be genetically modified has been developed by measuring the fluorescence of water-soluble protein.

**Article 3**

14. Red and yellow and… at least 70 other colours. A genetically engineered fish has skin cells in all the colours of the rainbow and then some. Its beauty is more than skin deep though – the huge variation in colour could be used to track individual cells as they develop, move and regenerate.

15. The "skinbow" zebrafish was created using a gene that codes for red, blue and green fluorescent proteins, although only one colour is produced at a time. Ken Poss at Duke University in Durham, North Carolina, and his colleagues injected this gene into single-cell fish embryos. In one particular embryo, this gene became incorporated into part of the genome that patterns skin cells.

16. As an adult, this fish looked reddish in colour, but when the team shone a UV light on its skin, it lit up in technicolour. "We didn't know these patterns would develop just in the skin," says Poss. "When you make genetically engineered animals, you can't fully predict the outcome."

17. Poss thinks that each of the fish's skin cells has about 100 copies of the gene. Whether each gene creates a red, green or blue protein is entirely random, he says. "One cell might have 80 red, 10 green and 10 blue proteins, for example," says Poss. Each cell could have one of about 5000 possible colour combinations, although the resolution of Poss's microscope only lets him distinguish 70 different colours among the cells.

**Regeneration and repair**

18. The fish and its offspring can be used to track how skin cells move to regenerate tissue and repair injuries – a task normally made difficult by the fact that individual skin cells look so similar to each other.

19. In one experiment, Poss's team took snapshots from one patch of skin, twice a day for 20 days. All the images were fed into a computer, with software that can identify and track each skin cell based on its colour. This allowed the team to work out that the entire population of the fish's skin cells turns over every 20 days or so, and that each cell spends about eight days on the surface of the skin before it wears off. The team also watched how the fish's skin responds to injury. The group snipped off part of a fin – an injury that zebrafish can usually repair. Skin cells in the surrounding area raced to the injury site, and doubled in size to cover the area of the damage. Deeper down, a sheet of new skin cells was created, which rose to the surface within half an hour.

20. "This approach lets us image cell dynamics in a live animal," says Poss. He hopes that the skinbow fish can be used to reveal more about how tissue regeneration occurs – a process that is still mysterious, he says. Christine Pullar, who studies wound healing at the University of Leicester, UK, agrees. "I can imagine that this group will be able to explore skin biology on a new level," she says. "I look forward to seeing more research on skinbow."

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