



PART 1

Read the text below and answer questions 1–13.

THE PECULIAR WORLD OF TARDIGRADES

A

Tardigrades entered scientific literature long before they became internet celebrities. In 1773 the German zoologist Johann August Ephraim Goeze described tiny creatures crawling through water films on moss and lichens and compared them to miniature bears, a nickname that survives in the popular term “water bears”. A few years later, Lazzaro Spallanzani—better known for work on reproduction and “animalcules”—coined the name *Tardigrada* (“slow stepper”), drawing attention to their deliberate gait under a microscope. These micro-metazoans, typically under a millimetre in length, inhabit an extraordinary range of environments: damp soil, leaf litter, freshwater sediments, alpine snow, and even deep-sea deposits. Their apparent ubiquity is partly explained by their ability to persist through environmental volatility. While many small invertebrates perish when moisture disappears or temperatures plunge, tardigrades have evolved survival strategies that allow them to outlast conditions that would be lethal to most animals of comparable complexity.

B

The phenomenon that made tardigrades famous is cryptobiosis, a reversible state of extreme metabolic suppression. When conditions become hostile—most commonly when water evaporates—tardigrades can enter anhydrobiosis, contracting their bodies and retracting their legs into a compact form known as a tun. In this condition, the animal’s metabolism drops to a minute fraction of normal activity, sometimes described as less than 0.01% of the usual rate. Water content falls dramatically, and many ordinary biological processes effectively pause. Crucially, cryptobiosis is not a form of active living under stress but a kind of biostasis: the organism survives by reducing the biochemical reactions that would otherwise generate damage. When moisture returns, a tun can rehydrate and resume movement, in some cases within hours, demonstrating that the shutdown is organised rather than simply a collapse.

C

How tardigrades protect cells during drying remains an active research area, and the answer is not identical across species. Early explanations emphasised trehalose, a sugar known in other organisms to stabilise membranes and proteins under dehydration. However, genome sequencing and biochemical studies suggest that some tardigrades produce relatively little trehalose and instead rely heavily on tardigrade-specific proteins, including intrinsically disordered proteins (often grouped as TDPs). These proteins can



undergo vitrification: as water is removed, they help form a glass-like matrix that immobilises cellular structures, reducing membrane rupture and limiting damage to DNA and other macromolecules. The debate, therefore, is not whether trehalose matters—sometimes it does—but whether proteins provide the dominant protective mechanism in many species. The emerging picture is plural: different lineages appear to converge on similar outcomes—survival through desiccation—by using different molecular toolkits.

D

Desiccation is only one axis of tardigrade resilience. Experiments have shown that some species can endure extreme cold and revive after thawing, while others tolerate brief exposure to high temperatures that would denature proteins in most animals. Pressure and vacuum have also been tested in controlled studies, partly because tardigrades live in environments ranging from mountaintops to ocean depths. Yet the limits are important. Survival is often highest when stress is applied gradually, allowing the animal to enter an appropriate protective state; rapid shifts can be more damaging. In freezing, for instance, the formation of ice crystals can puncture cells, and repeated freeze–thaw cycles may reduce recovery even when a single long freeze is survived. These findings underline that tardigrades are not magical exceptions to biology; their resistance depends on conditions, rates of change, and the organism’s capacity to deploy protective responses in time.

E

Radiation tolerance has attracted particular attention because ionising radiation can break DNA strands. Some tardigrades withstand laboratory doses that would be catastrophic for many organisms, and their resilience appears to involve both protection and repair. A protein known as Dsup (short for “damage suppressor”) has been investigated for its role in reducing DNA damage, apparently by associating with chromatin and helping shield genetic material from breaks. Even so, the passage from laboratory results to general claims requires caution. Radiation tolerance varies among tardigrade species, and the mechanisms may differ depending on whether exposure is ultraviolet, X-rays, or other sources. Moreover, laboratory doses can be far higher and more abrupt than those typically encountered in natural habitats. Nevertheless, the study of Dsup and related pathways has strengthened the hypothesis that some tardigrades possess unusually effective systems for managing DNA fragmentation.

F

The ecological reality is more ordinary than the legend. Tardigrades are most active in thin water films where they can feed, moult, and reproduce; prolonged cryptobiosis is a survival mode, not a lifestyle. Many species are sensitive to pollutants, and populations can rise or fall with microclimatic shifts in moss cushions and soil. Their survival in



extreme conditions does not imply that they thrive under them. A tardigrade in a tun is not foraging, not reproducing, and not “enjoying” hardship; it is enduring it. Researchers therefore emphasise context: to understand tardigrades as animals rather than as curiosities, one must examine their day-to-day constraints, life cycles, and interactions with microbes and microhabitats that determine whether populations persist.

G

Because the underlying mechanisms involve stabilising fragile biological material, tardigrades have become a target for biotechnology. If proteins can vitrify cells and preserve macromolecules during drying, similar strategies might help store sensitive products without constant cold chains. Researchers have explored whether tardigrade-inspired methods could improve the stability of vaccines, enzymes, or even human platelets during transport. The appeal is practical: refrigeration is expensive, unreliable in some regions, and a major barrier to distribution. Yet translation is challenging. Tardigrade biology is integrated across tissues and life stages, and what works inside a micro-metazoan does not automatically scale to industrial formulations. Many proposed applications remain experimental, but the research illustrates why tardigrades matter: they offer an empirical model for stress tolerance that connects basic biology to technological ambition.

Questions 1–5

Choose the correct heading for each paragraph.

List of Headings

- i** Genetic defence against DNA fragmentation and a protein linked to protection
- ii** A historical account of discovery and a broad ecological range
- iii** A low-activity state that enables survival during drying
- iv** Different molecular strategies for coping with desiccation
- v** Surviving severe physical extremes, but only under certain conditions
- vi** Evidence that tardigrades reproduce successfully during cryptobiosis
- vii** A single explanation that accounts for all tardigrade species
- viii** The claim that pollution is responsible for tardigrades’ resilience
- ix** Space travel as the main reason tardigrades have become scientifically important

1 Paragraph A



2 Paragraph B

3 Paragraph C

4 Paragraph D

5 Paragraph E

Questions 6–9

Choose **TRUE** if the statement agrees with the information given in the text, choose **FALSE** if the statement contradicts the information, or choose **NOT GIVEN** if there is no information on this.

6 The passage suggests that a single molecular explanation accounts for desiccation survival in all tardigrade species.

7 The passage indicates that repeated freeze–thaw cycles may reduce recovery.

8 The passage gives an exact recovery rate following repeated freeze–thaw cycles.

9 The passage states that the Dsup protein functions by shielding DNA from radiation damage.

Questions 10–13

Complete the summary below. Choose **ONE WORD ONLY** from the text for each answer.

Mechanisms and future uses

When facing dry conditions, the tardigrade retracts its legs and enters a state known as a **10** At a molecular level, special proteins may form a **11** matrix that prevents cellular collapse. Scientists are investigating whether these properties could improve the stability of **12**, enzymes, and human platelets during transport without constant **13**

Answer Key

1. ii
2. iii
3. iv
4. v
5. i



6. FALSE
7. TRUE
8. NOT GIVEN
9. TRUE
10. tun
11. glass-like
12. vaccines
13. refrigeration