STATE

DA VINCI DECATHLON 2021

CELEBRATING THE ACADEMIC GIFTS OF STUDENTS

IN YEARS 9, 10 & 11

SCIENCE

TEAM NUMBER ______________

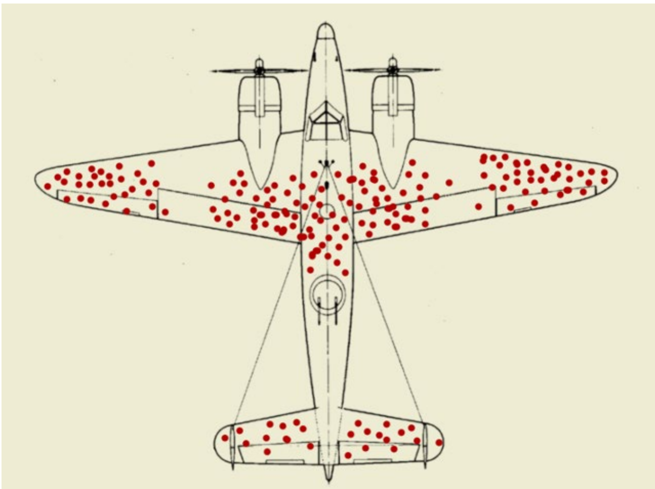
1	2	3	4	Total	Rank
/15	/15	/28	/14	/72	

QUESTION 1: CHEATING CHANCE (15 MARKS)

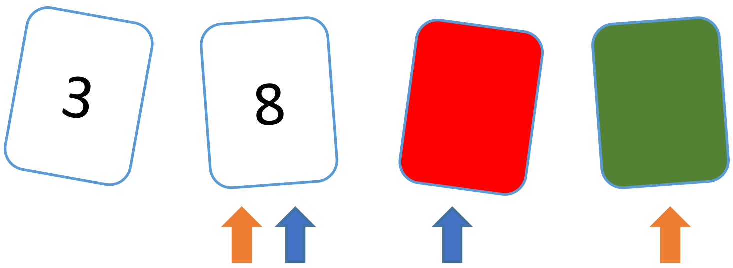
This first question looks at various errors in interpreting results from scientific investigations. The errors arose because scientists didn't correctly leave things 'to chance'. Instead, they added a bias to their logic, which meant the results from an experiment were no longer naturally occurring.

(a) Scientists reported a theory many years ago that 'cats who fell from higher stories have fewer injuries than cats who fell from lower down'. It sounds strange but was justified using terminal velocity by suggesting cats falling from higher than six stories reach their maximum velocity during the fall, so they start to relax and prepare to land, resulting in less injury. They collected data from various vets who recorded cats that were brought to their veterinary clinic after a fall. Theorise as to why this experimental method might have been fundamentally flawed, resulting in inaccurate results. (2 marks)

(b) In World War II, planes would return from flights with many bullet holes. Below is an image representing an average of the bullet hole locations, with each red dot illustrating a bullet hole. A team of engineers hoped to improve the resilience of the plane by installing extra shielding where it is most needed. Using similar reasoning to part (a), explain where the extra shielding would be best placed to better protect the plane. Annotate the diagram to indicate these locations. (3 marks)



(c) One of the most common biases in experimentation is confirmation bias. It arises when scientists interpret new evidence as confirmation of their existing beliefs or theories. Below are 4 cards used in an experiment. The participant in the experiment is asked: "which 2 cards should you turn over to test the claim that if a card has an even number on one face, then its opposite face is red?". Two possible selections are shown below using blue and orange arrows. Explain which of the two selections would be the most correct answer and which selection is the result of confirmation bias. (4 marks)



(d) The table below includes descriptions of four experiments, each with a different type of bias affecting the chances of collecting 'natural' data. Your task is to (1) describe the bias that is occurring in each example and (2) suggest an improvement to the experiment that would overcome the bias. (6 marks)

EXAMPLE	DESCRIPTION OF BIAS	IMPROVEMENT
An experiment aims to test how precisely high school students can estimate Australia's population. The survey each student received had 2 questions in this order: 1. Is Australia's population more than 30 million? 2. What is Australia's current population? Australia's population is 25.5 million but the average answer for question 2 was significantly greater, demonstrating the students were imprecise at estimating the population.		

A shoe company wants to maximise sales of their next product so release a survey: ‘what new product would you pay for?’. The survey was sent to the people who signed up the company’s subscription email list.		
A holiday program wanted to test the students’ satisfaction of its classes. One class provided feedback forms during the last class while a second class provided the feedback form a week after the last class. The results, shown below, show that class two was clearly more preferred. Class 1 – 78% satisfaction Class 2 – 91% satisfaction		

QUESTION 2 – STORIES OF SERENDIPITY (15 MARKS)

Many recognisable science developments have occurred by chance rather than purposeful experimentation. Microwave radiation, for example, was discovered after chocolate melted in a researcher's pocket. One of the greatest serendipitous discoveries is the alleged apple that fell on Newton's head.

(a) Consider the essential navigation tool: a compass. Imagine you discovered the compass by chance on one recent day after observing a few interesting phenomena. Your task is to describe the observations that you made to make this discovery and explain how these observations demonstrated the theories/scientific phenomena that explain how a compass functions. The quality of creative writing will not be assessed, rather the focus is on demonstrating an understanding of scientific principles. (3 marks)

(b) Most chance discovery in science resulted from observing nature. Below are various snapshots from nature. Your task is to match the list of technologies below to the correct natural source of inspiration and briefly explain what idea was borrowed from nature in each example. Note: the list contains more technologies than needed and there is no repetition of technologies in the table. (12 marks)

Kevlar, Space robots for external repairs on the ISS, Speedo swimsuits, Wind turbines, Bullet trains, Velcro, Multi-chimney cooling system, blu-tack.

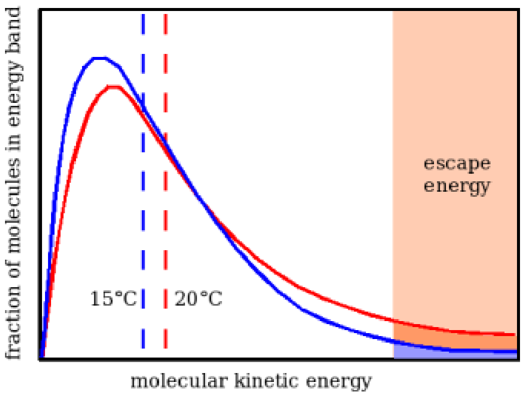
NATURAL INSPIRATION	TECHNOLOGY	EXPLANATION
		

QUESTION 3 – DRYING DILEMMA (28 MARKS)

Drying clothes, for many, often seems to be a game of chance. At times, in a heated house, clothes can take days to dry, while outside they take only hours even on cooler days. The science behind drying clothes, however, is quite simple. Firstly, the liquid water needs to be converted by energy to vapour. Secondly, an air stream is needed to remove the vapour. This question will examine this process more closely followed by considering an experiment that tries to determine the optimal conditions to achieve the fastest drying process.

(a) Temperature can be defined as the average energy of molecular motion. Within a shirt, for example, that is at a temperature of 15 °C there will be a number of different molecules of different energy, but the average of these will produce the temperature of 15 °C. At one particular temperature, we can map the percentage (fraction) of molecules at each energy level (energy band) as shown below. Explain why in the sketch below the red curve represents the shirt at 20 °C while the blue line represents the shirt at 15 °C. (3 marks)



(b) Molecules with a high enough energy, indicated in our sketch above as the percentage of molecules in the ‘escape energy’ shaded area, have enough energy to escape from the liquid water surface. Identify two forces that require a high energy for the molecule to break in order to escape the liquid water surface. (2 marks)

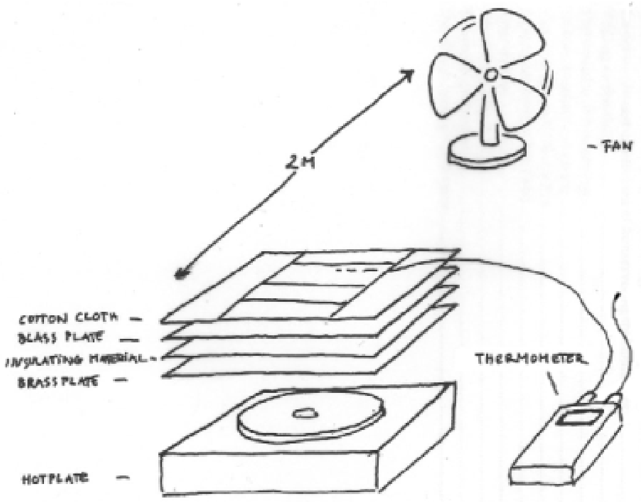
(c) Once molecules escape, the remaining molecules re-distribute their energy and consequently reach a lower temperature, indicated by the blue curve in the sketch above. By considering the liquid phase molecular model, explain how molecules can ‘re-distribute their energy’. (2 marks)

(d) On the sketch in (a) the lower temperature distribution (blue line) has a far lower proportion of high energy molecules in the escape energy area than the red line. Predict what this means for the rate of evaporation. (1 mark)

(e) In the drying of clothes, the process in (b) to (d) repeats indefinitely, causing the shirts’ temperature to vary until an equilibrium is reached. Explain what allows the process to repeat and predict what causes the process to reach an equilibrium. Will the equilibrium temperature be equal to, higher or lower than the ambient temperature surrounding the clothes (which are pegged to a non-conductive drying stand)? (4 marks)

(f) An experiment was designed to test whether heat, air or both are ideal for drying clothes. A description of the setup is below, using a cotton cloth to represent a piece of clothing. All clothing has a constant moisture content even when dry, about 9% for cotton. If this internally bound water is lost then cotton fibres will shrink and if misaligned during the process, the cloth will be permanently warped or shrunk. Ideal drying, therefore, is limited to drying the clothes without removing the 'dry' moisture content.

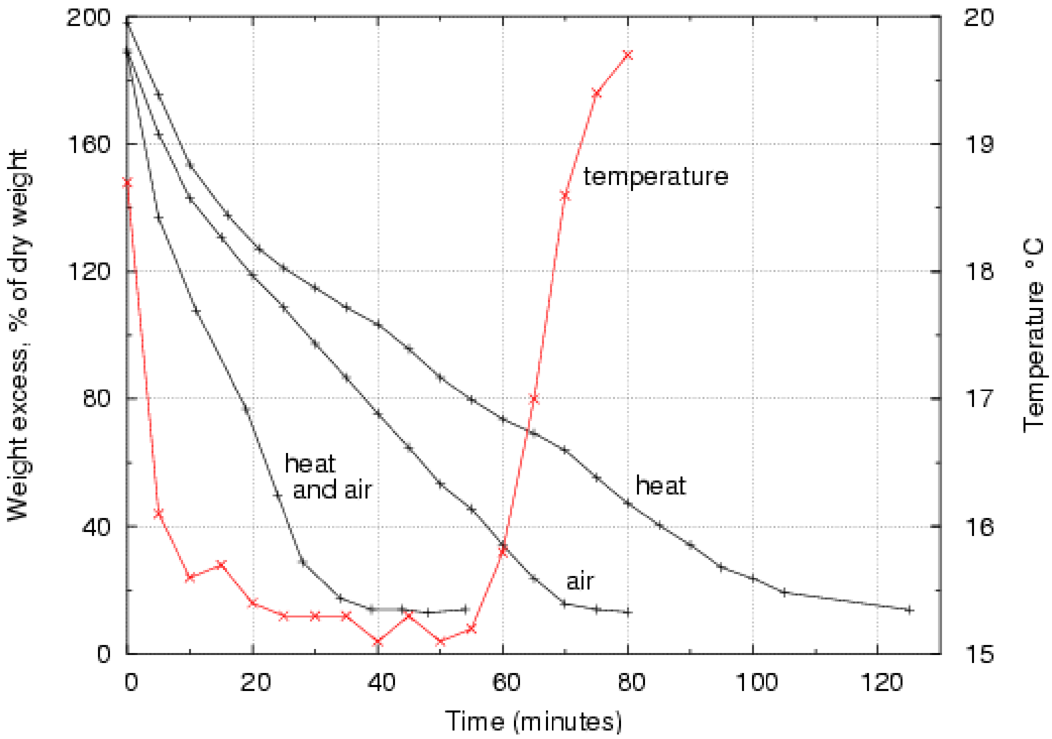
A wet cotton cloth is placed on a metal surface designed to spread the heat flow from the underlying, smaller, laboratory hotplate. The weighed portion of cloth is surrounded by a guard ring of cotton cloth which is also soaked at the beginning of each experimental run. The surface temperature of the cloth is measured by a fine thermocouple woven into the cloth. The heat flow from the hot plate is adjusted manually to hold the temperature exactly at ambient.



Complete the table below outlining key characteristics of the experiment. (6 marks)

AIM	
HYPOTHESIS	
INDEPENDENT VARIABLE	
DEPENDENT VARIABLE	
4 CONTROLLED VARIABLES	

(g) The results of the experiment are shown below. Each black trend line resembles a different test – one with only heat (to ambient temperature, 20 °C), another with only air flow and a final test with heat (to ambient temperature) and air flow. The data indicates over time the weight excess of the cloth (where 0% is the original unwetted cloth). The red trend line indicates the surface temperature of the cloth over time.

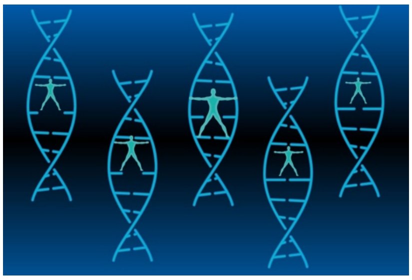


(i) Rank the three tests in terms of drying rate (slowest to fastest). Theorise the reason for these results using the principles developed throughout this question (4 marks)

(ii) The air flow only test exhibits a near constant rate of loss until around 70 minutes when there is a significant reduction until 80 minutes. This is unusual given that from 70-80 minutes temperature has increased almost 4 °C. Predict what is occurring at each stage to produce (i) the constant rate and then (ii) the reduced rate after 70 minutes. (3 marks)

(iii) The heat and air flow combined test exhibits a similar plateau from around 26 minutes, but in this case the temperature does not rise. Why might this be a concern and what test could be conducted to measure this concern? (3 marks)

QUESTION 4 – THE MEANING OF LIFE – 42? (14 MARKS)



If you've seen *Jurassic Park* then you might recall Dr Ian Malcolm forewarning: "*Your scientists were so preoccupied with whether or not they could, they didn't stop to think if they should*." This section will ask you to consider this question in relation to a rapidly developing field of science that is removing chance from our lifespans: life-expectancy prediction and anti-ageing technologies.

Household DNA testing kits are now readily available, allowing users to determine their chances of developing certain illnesses or the likelihood that a particular treatment will be effective for them. More recent research by scientists attempts to go one step further and predict your life expectancy.

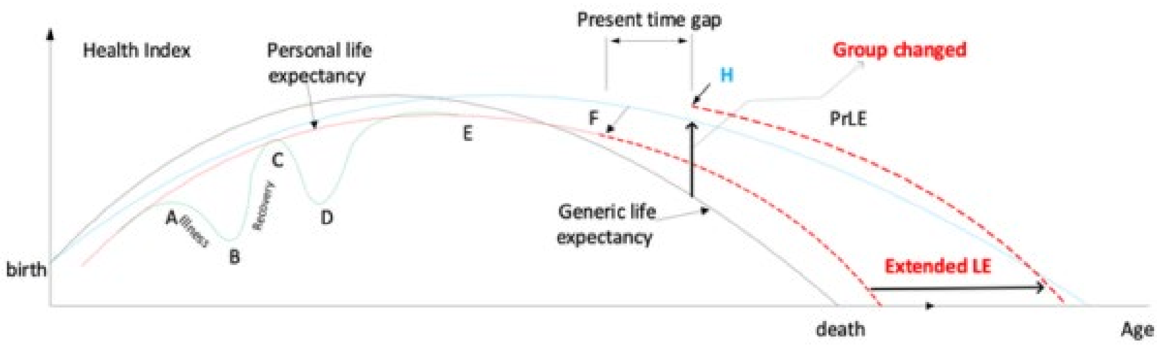
Using deep learning, artificial intelligence and predictive analytics, data scientists have been able to accurately calculate an individual's lifespan using a sophisticated system that considers a breadth of environmental, geographic, genetic and lifestyle factors.

Below is a recent article considering such technology that could remove an element of chance from the question of how long one could live. **Using the information below, and your own ideas, your task is to consider the implications of such life altering science to reach an evaluation as to whether it should be permitted as a technology for society**. To reach your conclusion, complete the short-answer responses below the article.

Much like existing tools that predict cancer survival rates, in the coming years we may see apps attempting to analyse data to predict life expectancy. However, they will not be able to provide a "death date", or even a year of death.

Human behaviour and activities are so unpredictable, it's almost impossible to measure, classify and predict lifespan. A personal life expectancy, even a carefully calculated one, would only provide a "natural life expectancy" based on generic data optimised with personal data. The key to accuracy would be the quality and quantity of data available. Much of this would be taken directly from the user, including gender, age, weight, height and ethnicity.

Access to real-time sensor data through fitness trackers and smart watches could also monitor activity levels, heart rate and blood pressure. This could then be coupled with lifestyle information such as occupation, socioeconomic status, exercise, diet and family medical history. All of the above could be used to classify an individual into a generic group to calculate life expectancy. This result would then be refined over time through the analysis of personal data, updating a user's life expectancy and letting them monitor it.



This figure shows how an individual's life expectancy might change between two points in time (F and H) following a lifestyle improvement, such as weight loss.

https://theconversation.com/dont-die-wondering-apps-may-soon-be-able-to-predict-your-life-expectancy-but-do-you-want-to-know-129068 (CC)

(a) Explain five benefits that arise from life-expectancy prediction. Each benefit must affect a different area (e.g. health, business, insurance, government, economics) and be explained (i.e. identify the feature of prediction that is beneficial and then justify why it is beneficial with reference to an area). (5 marks)

(b) Identify five risks associated with using such technology. (5 marks)

(c) By balancing the risks and benefits, along with considering which groups (e.g. individuals, government, business) would be most affected, evaluate how life-expectancy predictions should be used, if at all, in the future. If you believe it should be used in some way, explain whether this is unrestricted use or what possible limits you would apply. (4 marks)
