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For Supervisor's use only

TOP SCHOLAR

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Scholarship 2009
Science

2.00 pm Tuesday 24 November 2009
Time allowed: Three hours
Total marks: 40

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should answer ALL the questions in this booklet.

Each question is worth 8 marks.

Write all your answers in this booklet.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly

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Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

You have three hours to complete this examination.

QUESTION ONE: BATS AND ULTRASOUND

http://118.98.213.22/aridata_web/how/b/bat/bat-8.jpg

Bats, which are usually only active from dusk to dawn, use **echolocation** to detect their prey and find their way around in the dark.

Bats emit pulses of ultrasound of varying amplitude and frequency between 20 kHz – 160 kHz. Their highly sensitive ears catch the echoes. The size, shape and texture of objects can be determined, as well as their location, direction of movement and speed.

The echolocation is so sensitive that flying insects can be caught while the bat is flying fast, and even a tiny change in air current due to the wing beat of their prey can be detected.

Analyse the ability of bats to locate prey and navigate using ultrasound.

Consider in your answer:

- how bats determine the shape, size, texture and position of objects
- the Doppler effect
- why bats use ultrasound frequencies
- why ultrasound waves are sent out in pulses.

As bats are only active during hours of darkness this means they cannot use light as humans do to understand their surroundings. Bats use lower frequency ultrasound to detect further away objects as these will travel further than the higher frequency sounds as high frequency sounds have smaller wavelengths and vibrate more rapidly meaning they lose energy more quickly through transversion to heat energy (decreasing the amplitude) These higher frequency ultra sounds would therefore be used for closer objects as they ~~(illegible)~~ can tell more finer details of the object. Bats can tell details about the object by the return echo. Objects that are further away take longer for the ~~(illegible)~~ echo to

return and so using (d=vxt) the bats can work out distance. Also by the returning amplitude distance can be worked out as as ultrasound travels it decreases in amplitude due to loss of energy through transmission (vibrations of particles cause heat energy). Details of the objects can be worked out also by returning aplitude smooth, hard and shiny surfaces reflect more of the sound and absorb less and rougher, softer surfaces reflect less back and absorb more. Also bigger objects give a greater echo as smaller objects may not return as much due to some of the ultrasound going over or around the object (smaller surface area). Different textured objects absorb and reflect different amounts of ultrasound so bats can tell the differences. The position of object can be told by the angle of echo (angle of incident = angle of reflection), also bats ears are very sensitive and can note the angle the ultra sound is returned at. Soft bodied objects absorb more as they allow for internal reflection of sound which creates heat energy and decrease in amplitude due to a less dense object. Bats can also tell if their prey or the object is moving away or towards the bat. This is because an object moving closer will reflect a higher pitch (higher frequency) echo and an object moving away will produce a lower pitch (lower frequency). From this change in frequency

QUESTION TWO: THE ALBEDO OF ASTRONOMICAL OBJECTS

Albedo is a measure of the reflectivity of the surface of a planet, moon, asteroid, or any other celestial body that doesn't generate its own light. The albedos of such bodies provide valuable information about the structure and composition of their surfaces. This is especially useful if the bodies are small and far away.

Albedo is determined by calculating the amount of light that strikes the body and then measuring the reflected light. An albedo of almost 100% indicates a bright surface that reflects most of the light that strikes it, whereas an object with an albedo of almost 0% would absorb most of the light. The albedo will vary over the surface of a body, so an average measure is given.

The albedos of some solar system objects

Solar system object	Earth	Moon	Mercury	Venus	Mars	Jupiter
Albedo (average) %	34	7	6	85	15	41

The albedos of all the different features of the Moon's surface are accurately known. These are used as standard measurements so that measurements from other bodies can be compared.

Discuss fully the factors that will determine the albedo of solar system bodies.

Consider in your answer:

- the presence or absence of any atmosphere
- mineral composition and reflectivity of the surface
- the presence of surface liquid and/or ice
- possible cloud cover
- the importance of the angle the sunlight is shining on the surface
- the relevance of standard measurements.

The atmosphere of the planet or moon will have a big effect on the albedo as if it is a very thick atmosphere light will become scattered by objects in the atmosphere or absorbed meaning the reflection seen will either be only of that atmosphere or be severly reduced by the light transmitting through the atmosphere when going towards planet and also when being reflected back if there is no atmosphere the albedo % will be more true as an especially thick atmosphere will

The amount of light reflected back gives the albedo and as harder, smoother and shinier/brighter surfaces reflect more and absorb less they will have higher albedos. So for planets that have minerals that are denser and smoother/lighter this will give a higher albedo were as planets that have minerals that are softer and darker will absorb more light and so have a lower albedo. If there is surface liquid this will reflect more light and ice will reflect even more having a higher albedo. When light is reflected it follows the equal angle rule so therefore smoother surfaces will reflect the light more accurately were as rougher surfaces will scatter the light in different directions with reflection. Cloud scatters light within the pores and molecules of it so less light would be reflected out as clouds don't allow light to penetrate (like on earth on a cloudy day less sunlight gets to the surface) ~~Most atmospheres that are~~ ~~effected by~~ Standard/average measurments are taken as the average of a large number of trial ~~as the average of all the~~ measurments can remove any data error and make a more reliable result. Also it is important to have

QUESTION THREE: THE INFLUENZA VIRUS

Viruses reproduce by attaching their surface proteins to host cell membranes and injecting their genetic material into the cell, giving instructions to the cell machinery to make more viruses.

The influenza virus is an RNA virus with a very high mutation rate. This means that our immune system and the developers of vaccines are always trying to catch up.

Humans infected with the influenza virus develop antibodies, which bind to the "H" and "N" proteins found on the surface coat of the virus. The antibodies prevent subsequent infection only if the virus remains unchanged. However, if the RNA that codes for either the "H" or "N" protein mutates, then these antibodies will no longer bind.

Usually only one of the "H" and "N" proteins mutates each year. When humans are exposed to the mutated virus the next year, some of the antibodies will bind to the proteins and some will not. Those that bind to the non-mutated protein will still give some protection, but the antibodies against the protein that has mutated will no longer work. The infection will be mild but infect a lot of people. This process of gradual mutation leads to yearly epidemics of influenza.

Discuss fully the consequences of mutations of the influenza viral surface proteins.

Consider in your answer:

- the relationship between mutations and changes in the surface coat proteins
- why antibodies may no longer bind to mutated proteins
- a possible genetic reason as to why influenza is milder some years compared with other years
- why the influenza virus may have such a high mutation rate.

When a mutation occurs it ~~can~~ occurs as a change in the arrangement of bases. This change in the arrangement can occur as a point mutation where a few different things can happen. However the change in this arrangement (where ever or how severly ½ it occurs) will mean during the completion of protein synthesis this will form a different polypeptide chain of amino acids and ~~the~~ so the protein will end up folding up differenty. Therefore when a mutation occurs in a virus a different ~~virus~~ surface coat protein is produced. This means antibodies can no longer bind to the mutated protein as

The influenza virus has such a high mutation rate as this is its defence mechanism to survival. It has evolved to do this and they can reproduce quickly to pass on this mutation very quickly.

Antibodies are proteins created by cells in the human body that specifically binds to only that specific protein. So it cannot bind to a mutated protein as if is not the right shape. Mutations occuring in the RNA can be either a frame-shift or a substitution mutation and depending on the type of mutation and where it will effect how different the new proteins shape is and therefore how mild the virus is, as the more similar it is, the easier it is for antibodies to control and therefore milder. In a frame shift mutation, the deletion or insertion of one base will mean the whole arrangement of the code in that gene will either be moved forward or back one space. If this occurs at the end of the arrangement this will not have a big effect on the protein formed as the poly peptide chain will only be different at the end and as the chain starts folding from the beginning of the chain, the shape will not significantly change and there will be milder infections. If there is a frame-shift mutation anywhere else in the arrangement of the gene then the protein will be completely changed as the codons (3 bases) will code for completely different amino acids which means the

QUESTION FOUR: FISH AND FATS

Fish that live in cold water, such as cod, contain a high proportion of highly unsaturated fatty acids in their cell membranes.

Discuss how unsaturated fatty acids ensure that fish swim efficiently in cold water. Refer to the data in the table below. A labelled diagram may assist your answer.

The proportion of different fatty acids in cod liver oil

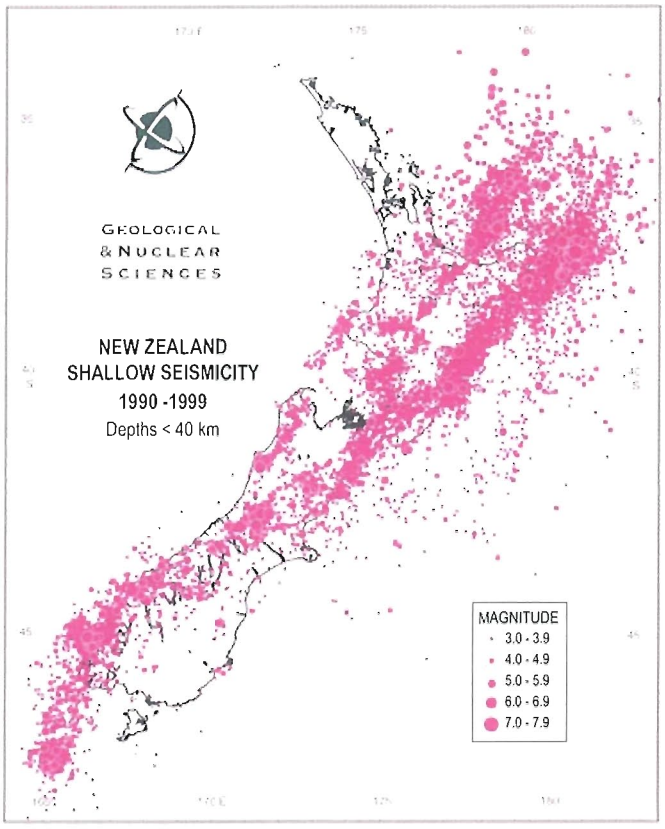
Fatty acid		
No. carbon atoms	**No. double bonds**	**% each fatty acid**
14	0	4
16	0	12
16	1	17
18	0	3
18	1	24
18	2	2
18	3	1
18	4	3
20	1	8
20	4	1
20	5	6
22	1	5
22	5	1
22	6	13
		100

As fish are cold blooded and live in cold water this means the fatty acids in fish need to have lower melting points, as if they were very high melting points the fatty acids would be very solid and therefore this would make the fish very heavy meaning they can't efficiently swim as would be sinking. The more unsaturated the fatty acid, the lower the melting point and less dense the fatty acids are as the more

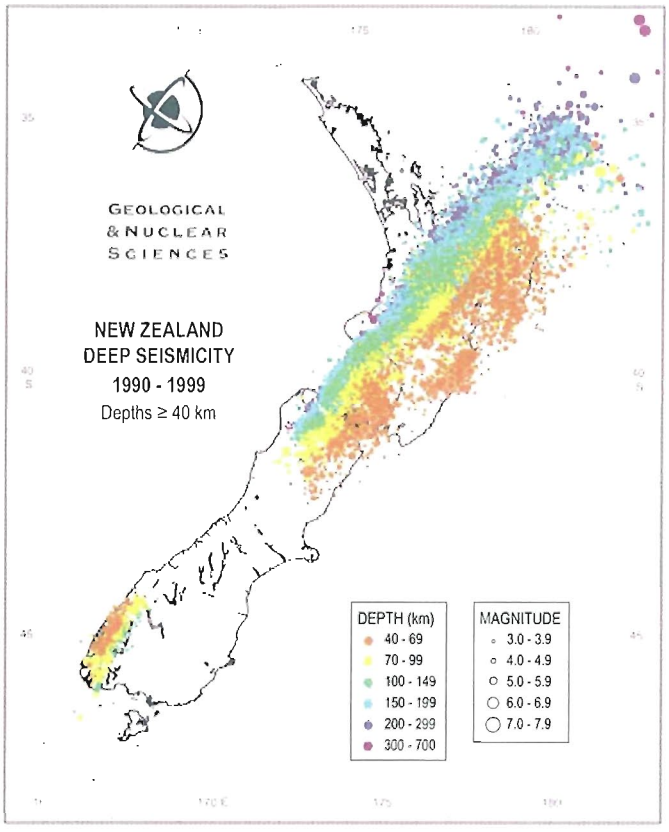
double bonds present. Double bonds change the shape making it less long and thin which means that there are less weak intermolecular bonds between fatty acids so it takes less energy to break the bonds (lower melting point → more liquid). It also makes more space between molecules of fatty acids joined which makes the fatty acids less dense. Another way to do this would be to have branched hydrocarbon chains in the fatty acids as this will create less temporary dipoles between two chains so lower melting point and create more space. The number of carbon atoms also effect the melting point of fatty acids with longer chains (more carbons) making more weak intermolecular forces (tempory dipoles) between

→ pg 14

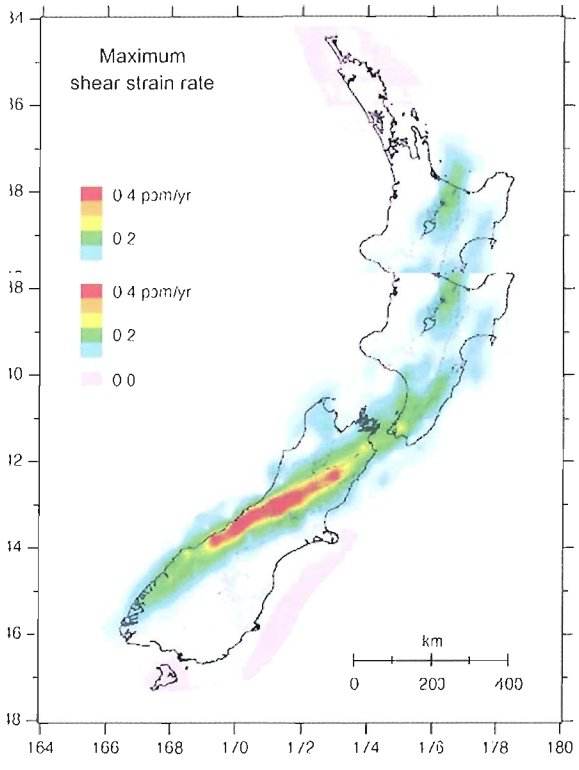
QUESTION FIVE: EARTHQUAKES IN NEW ZEALAND



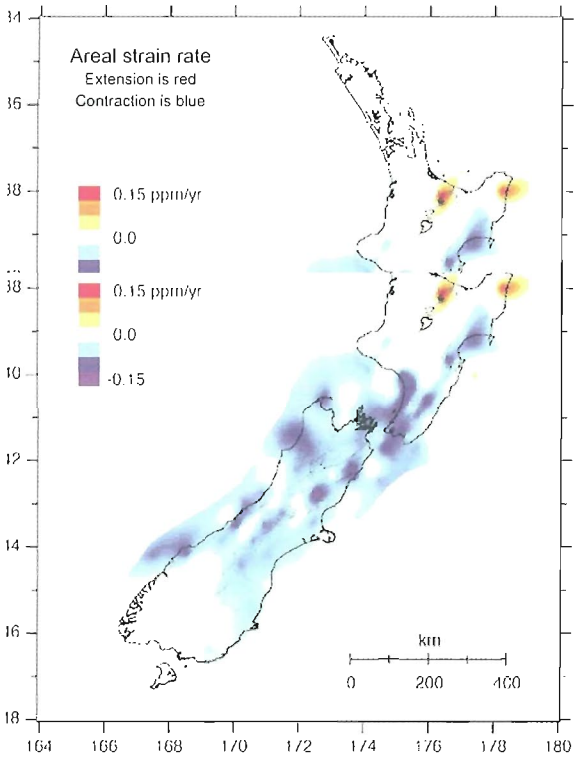
Map One: Shallow earthquakes, 1990–1999
www.gns.cri.nz/what/earthact/earthquakes/shallowseismicity.html



Map Two: Deep earthquakes, 1990–1999
www.gns.cri.nz/what/earthact/earthquakes/deepseismicity.html



Map Three: The rate at which sideways deformation is taking place. The red areas are those that are undergoing the most deformation.
www.gns.cri.nz/what/earthact/crustal/images/sheer_strain_rate_nov2003.gif



Map Four: The rate at which the surface of the ground is expanding or contracting. The areas expanding are red, the areas contracting are blue.
www.gns.cri.nz/what/earthact/crustal/images/areal_strain_rate_nov2003.gifnov2003.gif

Give justified reasons for the pattern of shallow and deep earthquakes over the whole of New Zealand. Use the four maps on page 10 to inform your answer.

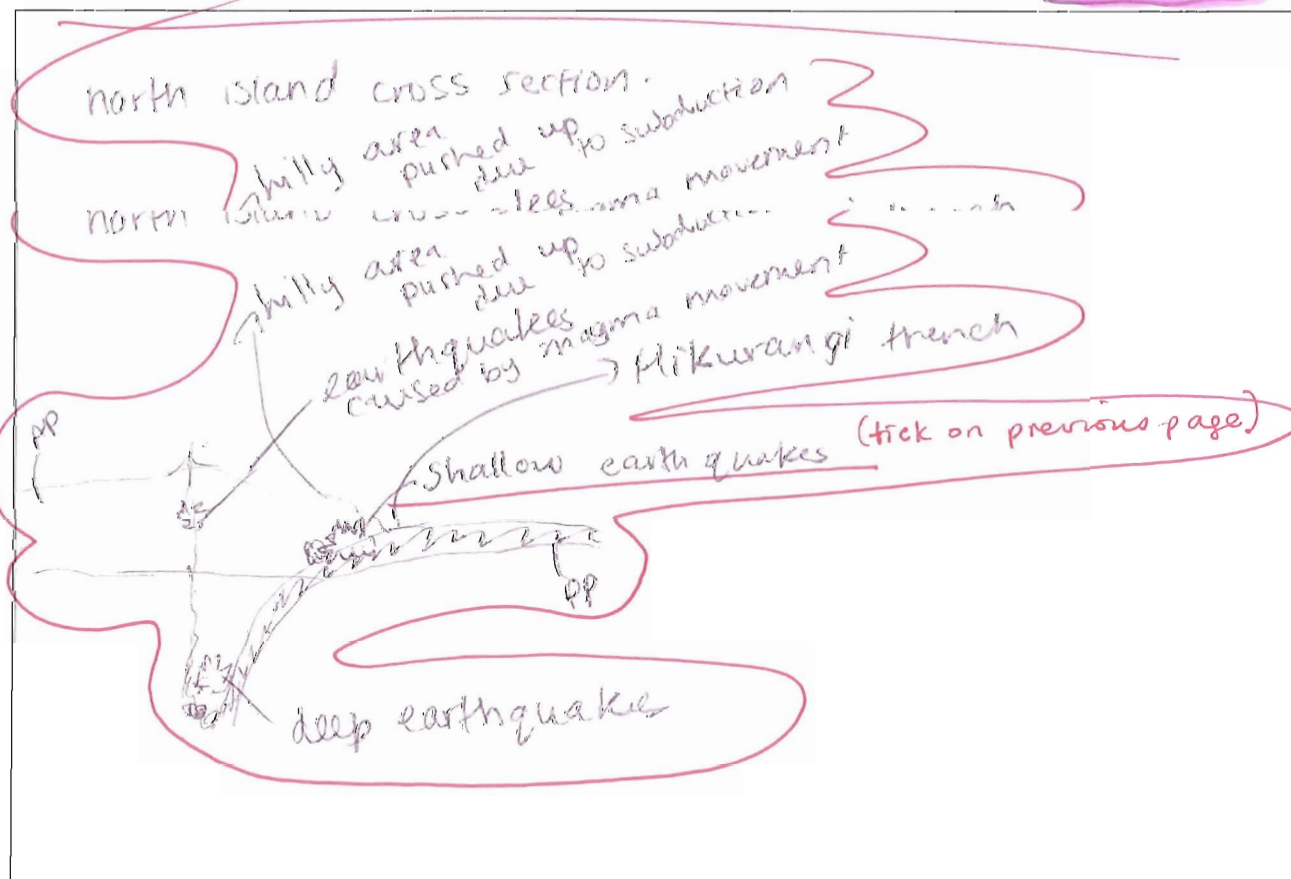
Diagrams may assist your answer.

The deep earthquakes located on the north island and bottom of the south island are caused by subduction. On the ~~top of the~~ north island the denser oceanic crust of the Pacific plate (PP) is subducting under the buoyant continental crust of the Australian plate (AP). As the PP is cold and brittle when it first starts subducting (as it has been moving along the ocean floor for a long time since its formation from the spreading zone of the coast of Chile) This means there are many earthquakes at a depth of <40 up to 69 km as this brittle cold crust causes lots of friction while subducting under the AP. As the PP is subducted more it warms up and so the deeper earthquakes are caused as the plate is deeper up under the AP causing friction. The spreading out of the deep earthquakes from right to left in the diagram show that the PP starts subducting quite shallowly and then very steeply as it goes from green → blue → purple more quickly then it goes from orange → yellow. In this subduction earthquakes also occur from the movement of magma which is created in this subduction as wet sediments are subducted with the PP. The water vapour in these wet sediments is released as the temp rises as the plate subducts further. This super heated

water vapour lowers the melting point of the rock forming a mixture of partially melted rock (magma) as this rises gas bubbles expand which creates pressure on the crust as this pushes its way up through cracks as expanding gas bubbles increase the volume of magma. This causes earthquakes and reason the gas bubbles aren't released from the magma is because the magma is either andesite or rhyolite so is therefore sticky enough to trap the gas bubbles. The viscousity of the magma is affected by the amount of silica in it. Andesite has 55-65% and rhyolite 65-75% silica, they both have high amounts as they gain silica from subducted ocean sediments and melted crust. At the bottom of the south island the oceanic plate of the AP is now subducting

→ pg 16

north island cross section.



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Extra paper for continuation of answers if required.
Clearly number the question.

Question number

1 bats can tell all sorts of details such as how fast the object is retreating or coming towards the bat ($v = \lambda f$). This change in pitch is called the doppler effect and helps bats to catch insects which are moving while the bat is moving as well. This works the other way round as well with if the bat is moving closer to the object the frequency and therefore pitch will increase and as the bat is moving away from an object the frequency and pitch will decrease. Bats use ultrasound frequencies as they have much smaller wavelengths then normal sound and so can give much more details, also humans have a hearing range of 20Hz – 20kHz and this is similar for some other insects. They are less likely to hear the very high pitched ultrasound as it is over its range so ~~[illegible]~~ the pulses won't warn prey so they can get away. Also if prey can hear at this frequency it may be just in their range which would cause confusion with high pitched pulses coming at them and echoing of walls aswell. Bats have specialised ears which can hear and understand this ~~[illegible]~~ ultrasound.

Extra paper for continuation of answers if required.
Clearly number the question.

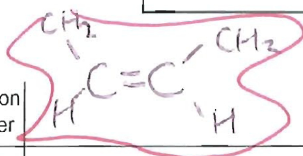
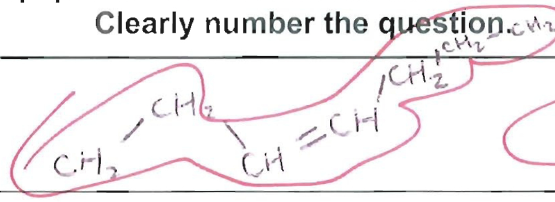
Question number

1 pulses are used instead of one continuous sound as this stops interference with the outgoing pulse and incoming echo. The echo is received between each pulse

4 and therefore a higher melting point (more solid fat) as it would take more energy to break more bonds. The fatty acids in the fish need to be more liquid. Fats and oils are made by joining a glycerol with fatty acids (joined with ester linkages) and depending on the fatty acids this will make the fat or oil, oils made with fatty acids which have lower melting points (more unsaturated or less carbons). Also even though a fatty acid is unsaturated it depends on if the double bond is a trans or cis isomer to if the melting point is decreased by more or less. Trans isomers mean the chain shape is not changed significantly so therefore the fatty acid

Extra paper for continuation of answers if required.
Clearly number the question.

Question number

cis

4 will only have a slighty decreased melting point. However a cis isomer means there is a kink in the shape this means that the melting point is significantly decreased. From the data this shows that for some fatty acids even though they have the same number of carbons so which have less ~~unsaturated~~ double bonds can still be an oil (liquid). e.g. 22 carbon atoms. with 1 double bond and 5/6 ~~the~~ the fatty acid is still an oil. This may be because the 5/6 double bonds could be trans isomers and the 1 double bond could be just a ~~trans~~ cis so the effect the one cis has and 5/6 trans lower the ~~boiling~~ melting point by the same amount as it would take similar energy to break the bonds between the fatty acid molecules (similar number of bonds). The density of the fatty acids would need to be similar density to the cold water otherwise the fish would either float (less dense) or sink (more dense).

Extra paper for continuation of answers if required.
Clearly number the question.

Question number

5 under the continental crust of the PP. It subducts as the oceanic crust is denser and continental crust is more ~~less dense~~ buoyent which is because oceanic ~~plate~~ crust is made out of denser rocks, mainly basalt and continental crust is made up of less dense rocks like granite. The subduction here is much steeper which you can tell as the distribution of orange → blue happens much more ~~less~~ quickly. As there is limited blue and no seen purple depth deep earthquakes this shows that the AP has not subducted as deeply as the PP has up north. This is as this subduction is newer than the subduction up north and for this reason their are no volcanoes due to subduction formed here yet. There are no deep earthquakes in the middle of the south island as the PP turns from oceanic crust to continental crust and so there is no more subduction. This is because when two continental crusts converge, they are both to buoyent so ~~more~~ neither can subduct. Instead the souther Alps are formed as the PP

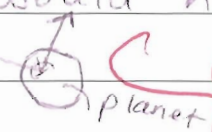
Fiordlands created here by PP pushing PP up slightly as it subducts

Achievement Standard Number ~~9~~ (Science Scholarship)

Question Number 2

Supervisor **must** print name & sign here :

standard measurements as they ~~did~~ cross check results as if it is known that eg earth ~~(erth)~~ has a very similar surface and mineral content to mars, it would mean that something was interfering with the amount of light being reflected on mars as the albedo is much lower. This may be from ~~a~~ atmosphere. The angle the sunlight is shining on the surface is important as due to the equal angle rule if it is reflecting at ~~it~~ not straight on the light would be reflected in a direction where we would not be able to record it e.g



Also light can be refracted by denser materials so the light could be reflected away from ~~the~~ viewing if there is a thicke dense ~~atmosphere~~ atmosphere

Achievement Standard Number 9

Question Number 3

→ scientia schol.

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polypeptide chain will be completely different and so the shape will also be completely different meaning there will be a ~~more~~ less mild infection as the antibody will definitely not work. A substitution mutation would change just one base in a codon and so in the amino acid chain only one amino acid would be different. A missense mutation (substitution) means there is one base changed and so ~~it~~ ~~the~~ as polypeptide starts folding from the start if the missense mutation occured nearer the end of the chain there would be milder infections and less mild infections if it occured earlier on. There would be no difference in the end protein produced if it was a silent mutation meaning the change in the base at the end of a codon still codes for the same amino acid (some amino acids have more than 1 codon coding for them) This would mean the same protein was produced from the same polypeptide chain and there would be no ~~infection~~ infection as the antibody would be able to bind to the protein. There would also be no infections if a neutral mutation occured as this means the change in a base of a codon codes ~~for~~ an amino acid that has the same chemical structure of the original amino acid. The polypeptide chain would then fold up very similarly and ~~the~~ almost the same protein made which the antibodies could bind too. In a nonsense mutation the change in base would then code for a stop codon (UAG, ~~UAA~~, UGA) meaning the polypeptide chain stops producing from ~~then~~ that point on. If occurs at end → sight difference mild infection, ~~if anywhere else then the protein would be incomplete so~~

Achievement Standard Number 9 Scholarship Science

Question Number 5

Supervisor **must** print name & sign here

is pushed over the AP. However acaross this area there is shallow earthquakes, this is due to the tranvese fault (Alpine fault) and other faults formed due to the sliding movements of the two plates. This causes lots of stress on the land in the surrounding area as the plates are also colliding. The build up of stress from this movement is released suddenly along the faults as they finally give way to the stress and this is how shallow earth quakes occur. There is still shallow earthquakes along where the subduction occurs as as explained earlier the initial subduction of the cold brittle crusts causes friction and this can build up with shallow earthquakes eventually occuring. The maximum shear strain rate map is showing the strain of the movement of the plates along the south Island. Where the most deformation is occuring (red area) this is where the southern alps are formed do to so much strain one rides up over the other. Also volcanic activity is shown for the north island with shallow earthquakes. The Areal strain rate map shows the plates colliding and causing strain on certain parts which results in contracting. The expanding shown in the map at the top of the north Island is formed from the expanding of the AP around the Kermadec ridge and Volcanoes