OXBRIDGE APPLICATIONS

ANSWER LIKE A PRO! **BIOLOGICAL SCIENCES, CHEMISTRY AND MEDICINE**

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7 TRULY TRICKY QUESTIONS… HOW WOULD YOU ANSWER?

The best way to practise these is to get a friend, sibling or parent to ask you them before you've read them through. That way you can practise your interview manner, as well as your way of answering.

QUESTIONS:

1. A chemistry problem: Imagine yourself across a table from your interviewer who you have just sat down with. After some initial pleasantries, your interviewer offers you a glass of water which he pushes in front of you:
   As you reach to take a sip, the interviewer stops you and asks "Before you take a drink, please calculate for me the number of hydrogen atoms that are in the water inside the glass."

2. "Please describe to me an example of evolution in action"

3. "Imagine I am a research funding organization and I am awarding grants to various research proposals. Why would I ever award funding to someone studying the mating habits of the Bolivian hairy shrew instead of someone studying a new cancer drug delivery mechanism?"

4. "Are humans still evolving?"

5. "Imagine two twin girls. Are their chances of developing breast cancer identical?"

6. "What safety precautions do medical professionals take when performing an X-ray and why?"

7. "Give me as many reasons as possible as to why fish are slimy"

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ANSWERS:

We asked Dr. Adrian Charbin, our graduate Biochemistry expert and part-time blogger, how he would approach these questions...

1. **Imagine yourself across a table from your interviewer who you have just sat down with. After some initial pleasantries, your interviewer offers you a glass of water which he pushes in front of you: As you reach to take a sip, the interviewer stops you and asks "Before you take a drink, please calculate for me the number of hydrogen atoms that are in the water inside the glass."**

   Now, when posed with such an unusual question, always remember Occam's Razor – the simplest solution is usually the correct one. The first thing to do is determine how much water you have. You can either ask, approximate or (my preferred approach) use algebra. As such, let us say we have x millilitres of water.

   Given that this is a chemistry question, it's a good guess that we should be trying to figure out how many moles of water we have. To do this, it is easiest to convert the volume of water that we have into grams. Hopefully from your GCSE years you will remember that pure water has a density of 1gram/ml meaning that x millilitres is equal to x grams. Then, as we know that the molecular weight of water is 18 (oxygen = 16, two hydrogens = 2), then we know that the number of moles of water is [x/18].

   So, knowing that we have [x/18] moles of water, how do we figure out how many hydrogen atoms are present? First, we should work out how many water molecules there are. Given that we know the number of moles, if we multiply this by the Avogadro constant (A) (which is defined as the number of constituent particles in one mole of a given substance), we will work out the number of water molecules:

   Number of water molecules: A[x/18]

   As we know that for every molecule of water, there are two hydrogen atoms, the final answer will be:

   Number of hydrogen atoms: 2A[x/18]

2. **"Please describe to me an example of evolution in action"**

   Now as for an example, there is a plethora of examples you could use! Many students will have learnt about the peppered moth and the industrial revolution at school and this is a sound example to use. However, your interviewer will always be impressed to hear about novel examples you may know of. For those applying for medicine, the rise of antibioticresistant diseases such as MRSA is very important to know about and is a topic being

increasingly covered in the media. For the natural scientists, an interesting example could be how the average size of edible fish such as cod and haddock is decreasing.

But what if your interviewer says…

"While those examples are all sound, all three examples are a result of human activity, be that pollution from the industrial revolution, the invention of antibiotics or the pressure we exert on fish stocks from commercial fishing. Can you think of any examples that do not include a human influence?"

This is a difficult question as there are extremely few definitive examples to discuss. The best option would be to discuss the study on deer mice from the sand dunes of Nebraska. Here the mice have two different coat colours, one a sandy colour, the other a blackish-grey. While historically, the environment these mice had lived had characterised by dark coloured soils, around 8-15,000 years ago, light coloured sand dunes began to appear in the landscape. Originally, the deer mice were all dark coloured and were well camouflaged against predatory owls and foxes. However, around 4,000 years ago, light coloured brown deer mice started appearing which were better camouflaged in the sand dunes. The many thousands of years delay before the appearance of sandy coloured mice is a result of having to wait for the correct gene mutation to occur to allow for selection to act upon it.

3. "Imagine I am a research funding organisation and I am awarding grants to various research proposals. Why would I ever award funding to someone studying the mating habits of the Bolivian hairy shrew instead of someone studying a new cancer drug delivery mechanism?"

This odd question is meant to throw you off slightly and that is the whole point. At its core, the question is asking why we should pursue research that doesn't appear to have any immediately tangible benefits. Surely the money is better spent on projects that will produce new technologies and economic rewards? If ever faced with a question of this variety, I recommend two distinct answers:

The pursuit of knowledge is a worthy goal in itself. This I feel is a very appropriate response, especially at somewhere like Oxford or Cambridge where many of the researchers will be working on seemingly obscure areas of science! Oxbridge dons are looking for young scientists who are thrilled by the aspect of discovery itself, not just the physical or economic rewards that may result from it, so don't be shy to say this.

It is impossible to predict what technologies will arise from research. To illustrate this point, I like to use my favourite example, which concerns the research of the scientist Thomas D. Brock. In the late 1960's, Brock was studying bacteria that lived on the edges of hot springs found in Yellowstone National Park, work that was certainly considered niche and side-line at a time when most his colleagues were focusing on the development of new antibiotics. In these hot springs Brock discovered Thermus aquaticus, a hyperthermophilic bacterium capable of living at temperatures (70 Celsius) that would kill most other living organisms. What was of most interest about this discovery was the fact that the enzymes inside the bacteria continued to work at temperatures that would have caused all other known enzymes to have denatured and stopped functioning. Industrial processes have long wished

for enzymes that could operate at higher temperatures as reaction kinetics speed up at higher temperatures. However, the most important consequence of Brock's discovery was the development of PCR (polymerase chain reaction) using an enzyme from Thermus aquaticus called TAQ polymerase. PCR was such a major discovery as the technique allowed for the amplification of a single (or a few copies) piece of DNA by several orders of magnitude, generating thousands to millions of copies of a particular DNA sequence. The inventor of PCR, Kary Mullis, would go on to win a Nobel Prize for PCR and the technique has become a staple tool in every biology lab in the world.

4. "Are humans still evolving?"

These questions require a clear and strong understanding of what evolution actually means and an interviewee should be ready to deploy a concise but accurate definition of the term in an interview situation. In this case, the idea that evolution is the change in gene frequency over time should be stressed.

Many students will claim that humans have become so advanced that we are no longer subject to any selection pressures as we are so able to mould our environment to suit our needs instead of needing to adapt to our surroundings. However, they would be foolhardy to forget that humans still face a myriad of selection pressures, especially with regards to health and disease. For example, the gene frequency of alleles that confer resistance to the development of AIDS following HIV infection has been increasing among populations where the disease is common showing that even over a relatively quick timescale, humans are indeed still evolving. Another example to discuss would be how the gene for sickle cell anaemia remains common in sub-Saharan Africa as a result of selection pressures from malaria. An enterprising interviewee could suggest what might happen to the frequency of the sickle cell gene in this population should malaria ever be eradicated.

5. "Imagine two twin girls. Are their chances of developing breast cancer identical?"

The first challenge in answering this question is to clarify what sort of twins we are talking about. Astute students will realize that different types of twins exist and in the context of this question, the interviewer is likely talking about identical or homozygous twins.

The first key point here is that homozygous twins are genetically identical so their genetic risk factors will be the same. A top student will have heard of the famous BRCA1/2 genes and the fact that certain alleles of these genes carry a much higher probability of developing aggressive forms of breast cancers. Indeed, if you are found to possess these faulty alleles, the doctor may recommend a double mastectomy at a young age to avoid the risk of the cancer developing at all, because if it does form, it is often a highly aggressive and untreatable form of the cancer.

The second key point is that while genetics contributes to your risk of developing breast cancer, the environment also plays a part. Environmental risk factors for breast cancer can include exposure to radiation, obesity, alcoholism, and exposure to hormones (such as through hormone replacement therapy following menopause onset).
The final point, which only top students will mention, is that luck plays a part too. Even if two identical twins live exactly identical lives, one might develop breast cancer and the other

might not. This is a result of endogenous cell processes during the course of cell mitosis and DNA repair that can lead to DNA mutations, and hence cancerous cells.

6. "What safety precautions do medical professionals take when performing an Xray and why?"

Safety precautions can vary on the setting, but generally speaking all precautions are designed to minimize the long term exposure of the medical professionals to the radiation. These include precautions such as the doctor or nurse standing behind a shield or leaving the room during the x-ray exposure. They will also wear a radiation exposure badge or monitor to track how much radiation they are exposed to during the course of their work. The patient, who hopefully receives radiation exposure from x-rays very infrequently, will not have any protection as this would block the path of the x-rays! However, should an x-ray be taken of the abdomen or legs, a lead shield will be placed over the reproductive organs. This is because our gametes, formed in either the testes or the ovaries through the process of meiosis, are especially susceptible to radiation damage and this damage can lead to incorrect development of the foetus during development, often with drastic or fatal consequences.

For the medical professionals, the largest risk associated with radiation exposure is the risk of cancer. So how does radiation exposure translate to increased incidence of cancer.

To answer this, we must think what happens when an x-ray (or gamma ray) travels through a cell at the atomic level. X-rays and gamma rays both belong to a range of radiation known as ionizing radiation. This is because when these high-energy forms of radiation collide with an atom, they transfer so much energy to that atom that the orbiting electrons around the atom can become so energized and excited that one is ejected. Imagine that in this case, the atom was an oxygen atom. If oxygen loses an electron, its resultant charge is O+. Being an already electronegative element, this loss of an electron means that oxygen is now incredibly eager to recover an electron and so will react with anything to rip an electron back into its orbital. These highly unstable and reactive chemical species we call in 'free radicals'. When you are exposed to radiation, a burst of these free radicals are created within your cells and start reacting with whatever is closest. While most these chemical reactions are inconsequential, some free radicals could react with your DNA, causing DNA damage and hence mutations. An accumulation of these mutations over time can lead to the formation of cancerous cells.

7. "Give me as many reasons as possible why fish are slimy"

- As protection from predation: Catching slippery fish is difficult with our human hands! If we look at predators of fish, we can see that have adapted to catch fish by impaling (eagle's talons, shark's teeth), ambushing and inhaling (stonefish, anglerfish) or poisoning them (Portuguese man of war).
- As protection from parasites and pathogens: An astute student might fathom that the slippery material covering fish is similar to the mucus coating in our trachea. Indeed this mucus layer on the fish can help trap pathogens and parasites from getting a foothold on the skin of the fish and making it sick.
- To reduce the co-efficient of friction: By reducing the friction as the fish moves through the water, it means the fish can expend less energy to travel through the water and can reach greater speeds.
- To signal to other fish: How do fish communicate? Fish can excrete hormones,

pheromones and alarm signs through their skin and these can they diffuse out into the surround environment through their mucus layer Insulation: The mucus layer may act as thermal insulation for the fish, minimizing heat loss to the surrounding water and therefore conserving energy.

Osmotic protection: What happens when you spend too long in the bath? The same can technically happen to fish! The movement of water across semi-permeable membranes means that depending on the fish and its environment (saltwater or freshwater), there is actually a risk to the fish of gaining or losing (dehyrdration!) too much water.

Can you think of any others?