Module 1 Student Questions

Brief History of Magnetic Resonance - Guided Inquiry Questions

1. From the information provided in the table, do you think it is fair to say that MR impacts multiple scientific disciplines? Use evidence to make your case.

   Ans: The MR information can provide information about the local magnetic environments of the atoms in the sample, and this information can be used for determining chemical structure, 3D imaging, or as qubits for a quantum computer. MR is multidisciplinary since it has impacted multiple scientific disciplines as evidenced by the Nobel Prizes in physics, chemistry, and medicine.

2. What voices are we missing in this brief history of magnetic resonance? Would this in any way affect its overall impact? Why or why not?

   Ans: All of the pioneering voices in MR tech (ie all of the Nobel winners) were white guys. As seen time and time again, cultural diversity in a field causes more ideas to be created. Diversity is important for literally every field and as MR tech is still an actively growing area, diversifying it would greatly help it find uses where it might otherwise have been passed over.

Different MR Technologies - Guided Inquiry Questions

3. What are common elements of the different apparatuses that utilize magnetic resonance?

   Ans: All of the apparatuses use electromagnetic radiation and magnets (of different forms) to interact with different atomic components of the sample (either nuclei, electrons, or qubits). Presumably, there is some form of resonance happening as well in all of the cases to acquire the data.

4. What are some apparent differences between these apparatuses? Why might this be the case?

   Ans: The apparatuses use different frequencies in the electromagnetic spectrum. This enables them to interact with different atomic components (radio frequencies for interacting with nuclei and microwave frequencies for interacting with electrons). All the apparatuses can then provide different information about the sample or explore different types of samples.

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Spectroscopy and Imaging - Guided Inquiry Questions

5. What similarities and differences does NMR spectroscopy have compared with the other types of spectroscopy listed?

   Ans: All forms of spectroscopy use electromagnetic radiation of some form to provide chemical analysis of a sample for a variety of different applications. Only NMR has its signal coming from nuclei, uses a magnetic field, and uses electromagnetic radiation in the radio frequency range.

6. Why might scientists choose to use NMR spectroscopy instead of other spectroscopy techniques? When might other spectroscopy techniques be more suitable?

   Ans: Scientists may use NMR spectroscopy instead of other techniques because of the advantages that NMR spectroscopy is able to provide. It provides intel that other spectroscopy cannot and has lots of potential uses, whereas other spectroscopies are fairly specialized.

7. What similarities and differences do MRI and other imaging modalities have?

   Ans: All of the imaging types use electromagnetic radiation of some form to create non-invasive 3D imaging for medical diagnoses. MRI uses much lower energy electromagnetic radiation (radio waves) compared with the other imaging modalities and is generally a safe procedure as long as there are no metallic implants in the patient.

8. Why might scientists choose to use MRI instead of other imaging technologies? When might other imaging techniques be more suitable?

   Ans: Each imaging type has a different use and risks involved so doctors have to choose an option that both will be able to detect what problem they think is present while also making sure the patient won't have an adverse reaction to the procedure. Some of the imaging types such as CT scan PET/SPECT can be dangerous as they use ionizing radiation or radioactive material which can cause cancer if used too frequently. MRI uses strong magnetic fields that could cause injury to someone with metal in their body.

Reflection Questions:

1. How might having access to information about the magnetic environment of atoms be useful? What industries could make use of this information? What scientific questions could potentially be explored?

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Ans: Having something like a database of MR responses of different molecules would be incredibly useful for a lot of industries. The first that comes to mind is pharmaceutical companies can use MR to test the purity of a sample without destroying it. For any sort of medicine, it is incredibly important that what is being used is exactly what it is supposed to be, and being able to non-destructively check for contamination is incredibly valuable. The growing quantum computing industry also appears to be using the magnetic environment of atoms to control and encode information in qubits to replace classical bits in computers. There are lots of questions that could be explored regarding the quantum realm and a lot of potential for developing future applications and technologies.

2. Do magnetic resonance techniques provide any information beyond the other technologies shown here? Any advantages or disadvantages?

   Ans: MR is an incredibly useful tool due to the unique information it provides (e.g. accessing information from nuclei as well as electrons) and the abundance of applications in different scientific disciplines. However, like all scientific tools, it has its limitations (primarily requirements of applying large magnetic fields).

3. Do you think magnetic resonance techniques have passed their prime? Why or why not?

   Ans: No, new MR technology is still being developed (like the example of solid-state qubits), as well as constant developments of different spectroscopy and imaging techniques. Also, MR is starting to become accessible to more places such as educational institutions. Thus it is incredibly important to keep MR information up-to-date, and teaching students about technology actually used in the world better prepares them for future work.

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