Energy in Systems

Energy is not a physical thing. It is a **characteristic of a system**. We cannot measure energy directly, but we can see indicators of energy transfer. For example, our bodies are systems that stay warm and move. Changes in temperature and motion are indicators of energy transfer that we can measure.

Energy transfer in our bodies usually involves chemical reaction systems of biological molecules. We have already represented the chemical reaction system of **cellular respiration** in both words and symbols:

 $\begin{array}{l} {\rm Glucose + oxygen} \rightarrow {\rm carbon\ dioxide + water} \\ {\rm C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O} \end{array}$

All atoms and molecules have energy associated with them. The exact amount of energy varies for different molecules depending in part on the number, type, and arrangement of its atoms. The number and arrangement of the atoms in glucose and oxygen molecules shown in the chemical reaction system have a certain amount of energy associated with it.

When these molecules react to produce carbon dioxide and water, some of the energy is transferred from the reaction system to our muscle system and some is transferred to the surroundings. The rest of the energy associated with the glucose and oxygen molecules is now associated with the carbon dioxide and water molecules produced in the reaction.

We can represent energy transfer from this chemical reaction system to the muscle system of an individual in the diagram below. Higher energy is always shown at the top of the diagram. The thin arrows inside each system indicate change from before to after in time.



We can see evidence of this energy transfer to the muscle system when we observe an increase in muscle movement. We can see evidence of energy transfer to the surrounding environment by measuring the increase in muscle temperature and observing that we get warmer during exercise.