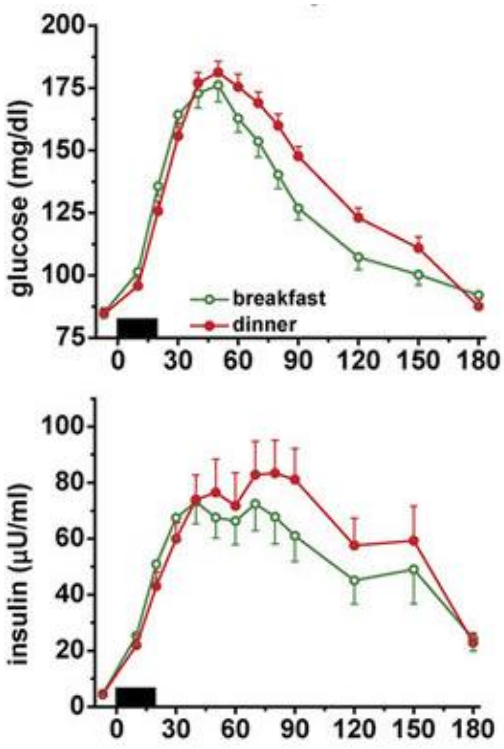
5. Metabolism throughout the day

Insulin is a hormone produced by the pancreas. As a result of insulin's action, glucose gets taken up from blood into tissues, where it is stored and utilised to get energy.

The graphs below come from a study[1] in which blood glucose (left graph) and insulin levels (right graph) of healthy individuals were measured after identical meals were eaten at breakfast time and at dinner time. On the x-axis, time is in minutes; the black bar represents the 20-min test meal; and the data is the average of 8 individuals.



Interpret the graph. What is happening with blood glucose and insulin after a meal? What similarities and differences between breakfast and dinner are observed? You could use the concepts from "Regulation of metabolism by cell signalling" resource.

You would have noticed the difference in postprandial (after a meal) blood glucose and insulin decline between breakfast and dinner. Other studies have shown similar patterns[2]: for example, during constant glucose infusion over 30 hours, lower glucose tolerance (how fast glucose goes down) is observed at night, i.e. levels of blood glucose at night are elevated compared to daytime when the sugar is supplied at a constant rate throughout the day-night cycle. This all points to glucose levels being affected by the time of day, and the mechanism behind this is our body's circadian rhythms. Why do you think such time-of-day differences in how blood glucose levels are maintained exist?

The **circadian** clock is an endogenous biological mechanism that drives roughly 24h cycles in various physiological processes.; This clock allows our body (and individual cells) to modulate responses to stimuli throughout the day.

To find out how circadian rhythms link the external environment with our physiology, watch this short simple cartoon introduction:

https://www.youtube.com/watch?v=2BoLqqNuqwA

The video mentions that shift workers have an increased risk of some diseases, including type 2 diabetes. How do you think that fits with the studies mentioned above?

References

1. Morris, C., Yang, J., Garcia, J., Myers, S., Bozzi, I., Wang, W., Buxton, O., Shea, S. and Scheer, F. Endogenous circadian system and circadian misalignment impact glucose tolerance via separate mechanisms in humans. *Proceedings of the National Academy of Sciences* 112, E2225-E2234 (2015).
2. Cauter, E., Desur, D., Decoster, C., Fery, F. & Balasse, E. Nocturnal Decrease in Glucose Tolerance During Constant Glucose Infusion. *The Journal of Clinical Endocrinology & Metabolism* 69, 604-611 (1989).

Circadian clocks and metabolism, recommended extra resources

1. A “Naked Scientist” podcast exploring circadian rhythms from many perspectives: https://www.thenakedscientists.com/podcasts/naked-scientists/clock-science-circadian-rhythm

   A great introduction into basic mechanisms in the beginning, followed by a very relevant discussion of recent studies on links between body clocks and obesity/diabetes (https://www.thenakedscientists.com/articles/interviews/body-clocks-obesity-and-diabetes)
   Other topics covered include sleep and light exposure, as well as an evolutionary perspective on circadian rhythms.

2. The Nobel Prize in Physiology and Medicine 2017 was awarded for the discovery of the molecular basis of circadian rhythms to three scientists who worked on the fruit fly Drosophila to discover genes involved in the animal clocks. Find out more about their discoveries in this 6-min video: https://www.youtube.com/watch?v=M-Tdvu3N8dA&feature=youtu.be&t=27