Teacher notes and Hands-on Activity for

Homeostasis: Negative Feedback Pathways in the human body

Karyn Coulon, Masconomet Regional High School
Topsfield, MA

This lesson narrative is intended to assist educators in teaching the central concept of homeostasis to entry-level Biology students and includes a kinesthetic game where students will actively engage in learning about the mechanisms that maintain blood glucose levels in humans.

Unit Topic: Homeostasis

Central Concept: The human body functions through a series of negative feedback pathways. The human organ systems work together to achieve homeostasis. There are a variety of mechanisms and vital functions that are maintained through homeostasis; blood glucose, blood pH, blood pressure, body temperature, O2 and CO2 levels, etc.

Key Terms

Homeostasis, negative feedback, stimulus, receptor, integrating center, effector/target organ, hormone, insulin, glucagon, pancreas, glucose, glycogen

Lesson Part 1 (Day 1): Homeostasis-general overview

Introduction: Prior Knowledge

"*What does the word "feedback" mean? With what do you associate this term?"*

The teacher will guide a brief discussion on what feedback is. An example would be students receiving progress reports. We will discuss the purpose of progress reports; for students to gauge their performance in there classes.

Students will be asked, "*What would you consider normal or acceptable range for your grades? What happens when you fall outside of (below) that range?"*

Students should identify that they have to do work and change their behavior in order to get back into that acceptable range.

The teacher will explain that the human body works in the same fashion through the process of homeostasis. The teacher will ask, "*What things/processes in the human body need to be kept within a particular range?"* Students will generate a list of processes. Further knowledge: Identity the target ranges for those processes.

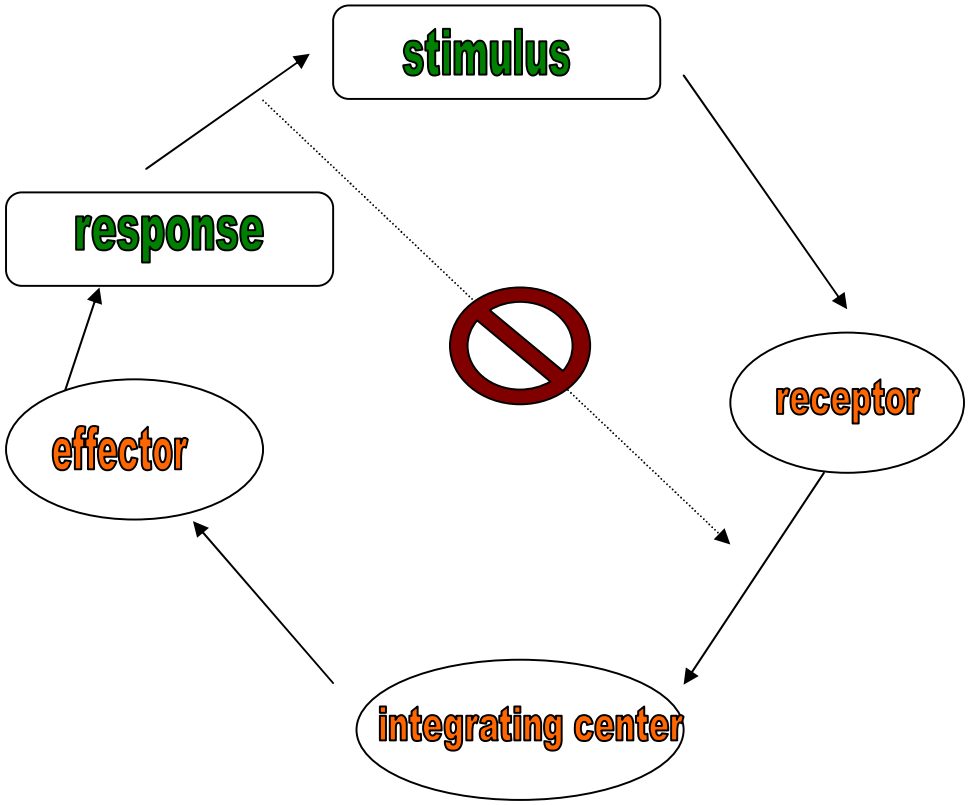
Main Lesson and Activity

(Materials for this part of the lesson courtesy of Susan Mickey, Salem High School, Salem, MA)

Students are given a worksheet with the terms stimulus, receptor, integrating center, effector, and response. They will define these terms based on the analogy of a home heating system. After reading about how a home heating system works, they will identify stimulus, receptor, integrating center, effector, and response in the story. They will then be given three human conditions that are controlled by negative feedback; thermoregulation-hot and cold, blood pressure, and O2/CO2 levels. Students are separated into four groups (4-5 students) and each group is assigned a different process. The teacher gives each group a very brief description of that process.

1. The group members read their description.
2. Identify the stimulus, receptor, integrating center, effector, and response and write these on paper in a list.
   Ex. Thermoregulation
   Stimulus= increase in body temperature

3. The groups now put these components into a flow chart, showing it's cyclical pattern. They will also indicate where the negative feedback occurs and the system is shut down. Using the basic flow chart below.



4. The groups will report back to the class, sharing their findings and flow chart.

Wrap-up

For homework, students will be instructed to identify the organ systems that are involved in each of the homeostatic processes that were explored in class.

For upper level classes, students will be asked to investigate the homeostatic process that governs blood sugar regulation. This can be done in their text book or an outside resource, such as the internet.

Lesson 2 (Day 2): Blood Sugar Regulation

Preparation

Print out copies of the attached "game pieces". It is suggested to print them on card stock and/or laminate them for re-use. You should print several (25-40) copies of the "Glucose" and "Insulin" cards. Print 5-10 copies of the "Circulatory System" cards, as you can assign several students to this role. Print one copy of all other cards.

Introduction: Prior Knowledge

Students will use information gained in the prior lesson in order to understand how the human body regulates blood sugar levels. The teacher will conduct a brief overview of what was learned in the prior lesson. Students will then be asked, *"What happens in our bodies after we eat? What type of nutrients/molecules are in those foods?"* A list will be generated on the board based on student response. The teacher will turn their attention towards foods containing carbohydrate. Students will be asked, *"What do carbohydrates provide for our bodies, our cells?"* (This should be review of macromolecules and cellular respiration)

Main Lesson and Activity

The teacher will briefly explain that our cells need a consistent and readily available supply of glucose in order to produce ATP and therefore maintain vital functions. The teacher will show a flow chart of the blood sugar regulation feedback loop, connecting this to the diagrams they generated in the previous lesson. Students will be asked to identify the stimulus, receptor, integrating center, effector, and response to both an increase in blood sugar, and a decrease in blood sugar. The teacher explains how the blood sugar regulation mechanisms work under normal circumstances.

The classroom now becomes the human body and students will kinesthetically demonstrate this process as a class. Students will be placed into teams based on organ systems and each will be assigned a specific structure and task. See the chart below.

System	Structure	Task
Digestive	Mouth (1 student)	Tear the starches in half and pass to stomach
	Stomach (1 student)	Break sugars into monomers of glucose and pass to sm intestine
	Small Intestine (1 student)	Pass the glucose to the circulatory system
Circulatory	Blood (multiple students)	Carry glucose to muscle, liver, brain
	Blood (multiple students)	Carry insulin to target organs
Endocrine	Pancreas (1 student)	-Command B-cells to release insulin. -Stop insulin production when needed.
	Beta cells (could have 2 or more students)	Pass insulin to the circulatory system when told
Target organs	Muscle (1 student)	Takes insulin from blood <u>first</u>, then can then take glucose from blood
	Liver (1 student)	
	Brain (1 student)	

Set up this homeostasis game in a circular pattern and instruct the students as follows (see powerpoint for game lay-out):

- The (student representing the) mouth is given a polymer of starch, made from the included glucose monomers. He/she is instructed to tear it in half and pass the halves to the stomach.
- The stomach separates the remaining pieces into individual monomers and passes them to the small intestine.
- The small intestine passes the glucose, individually, to one of the circulatory “runners”
- The circulatory runners will walk around the room in a circle.

- The pancreas will call out how many runners pass with glucose, calling out "Glucose!". After he/she has counted out five runners with glucose, he/she will instruct the β-cells, "Release the insulin!"
- The β-cells will pass insulin (from the provided templates) to any circulatory runners who are not carrying glucose.
- The insulin runners will pass their insulin on to the target cells (brain, liver, muscle).
- Once the target cells have insulin passed to them, they can take glucose from the glucose runners. ****Target cells can only receive a glucose monomer if they are holding an insulin key.*
- The circulatory runners continue to circle around the room. The pancreas calls out, "Stop insulin production!" once there are no more glucose monomers being passed.

This is the end of the game. The teacher may choose to have students switch jobs and then run the game again (if time permits) to give students more exposure to the function of different organs/structures in this process.
The game can also be adapted to include glucagon, α-cells, and glycogen. These pieces will need to be designed and printed.

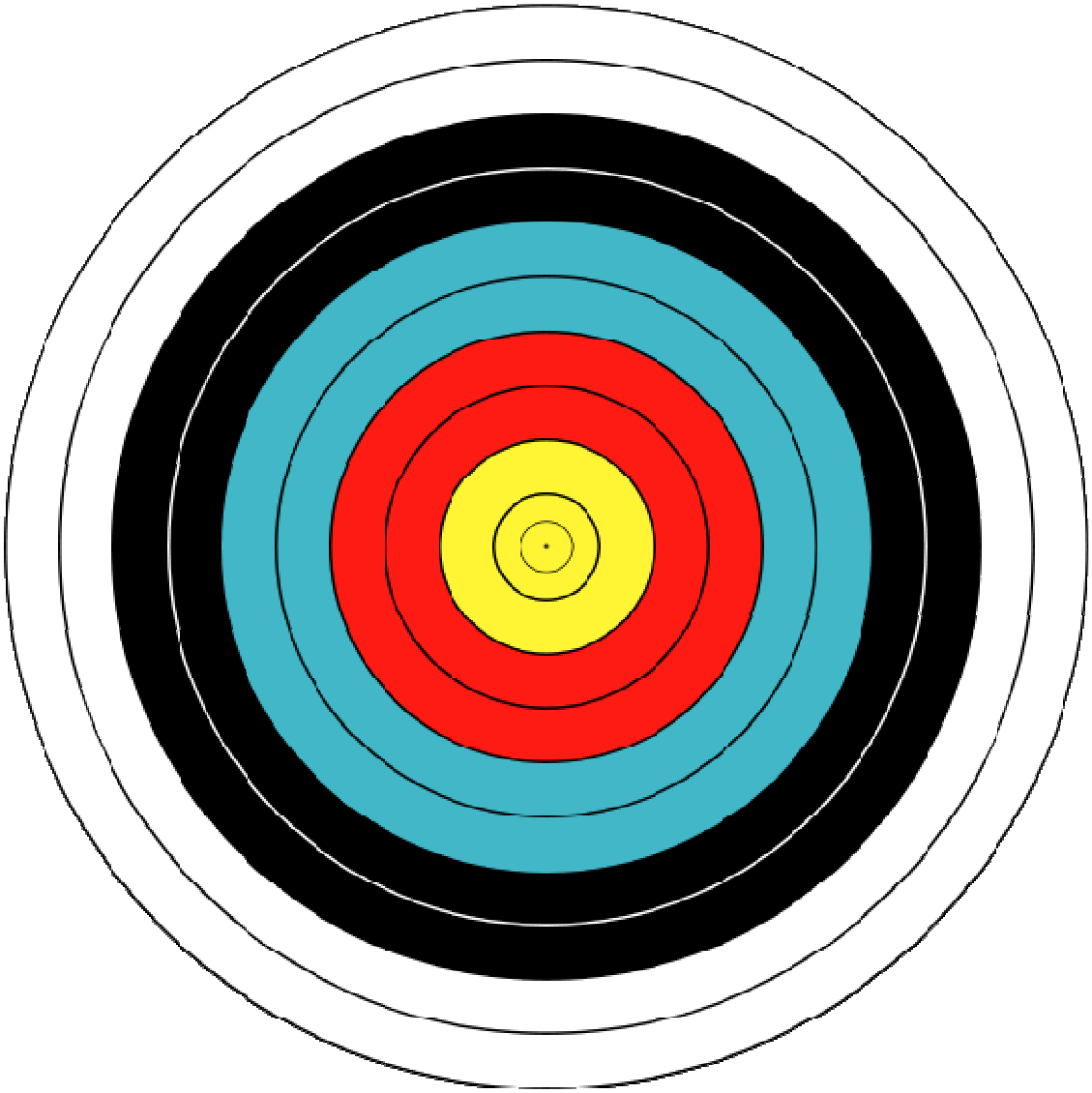
Suggested wrap-up to the activity
Have students return to their desks and write a brief description of the activity they just did. Make a list of their classmates, what role they played, and what task they had to perform.

Follow-up exercise

What happens when there is too little glucose in the blood?

The teacher would now explain how glucagon works in opposition to insulin, in order to maintain normal blood sugar levels.

Resources
Lesson material for "Day 1" lesson provided by and in collaboration with Susan Mickey, Salem High School, Salem, MA



Muscles

http://en.wikipedia.org/wiki/File:Archery_Target_80cm.svg

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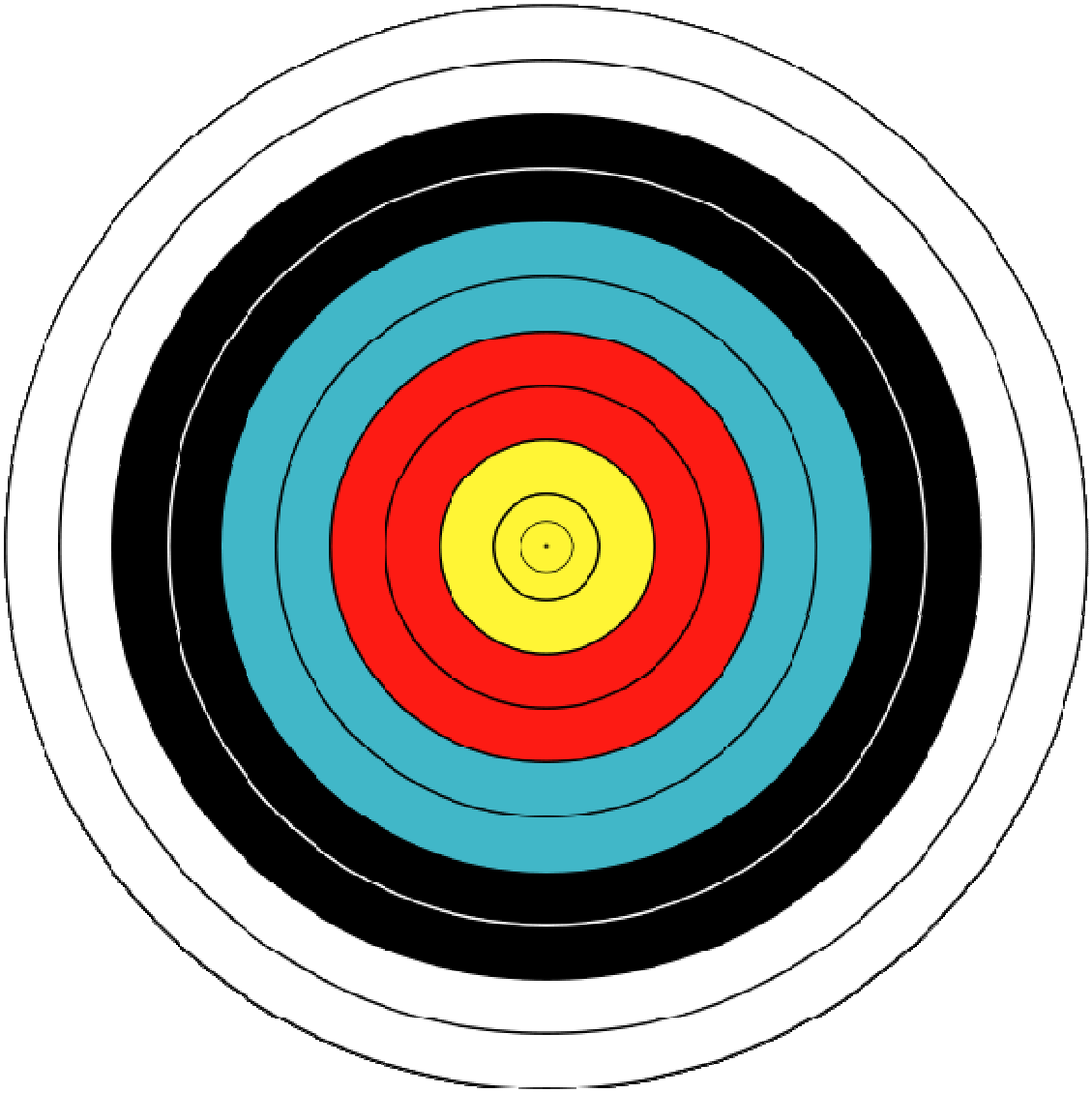

Brain

http://en.wikipedia.org/wiki/File:Archery_Target_80cm.svg

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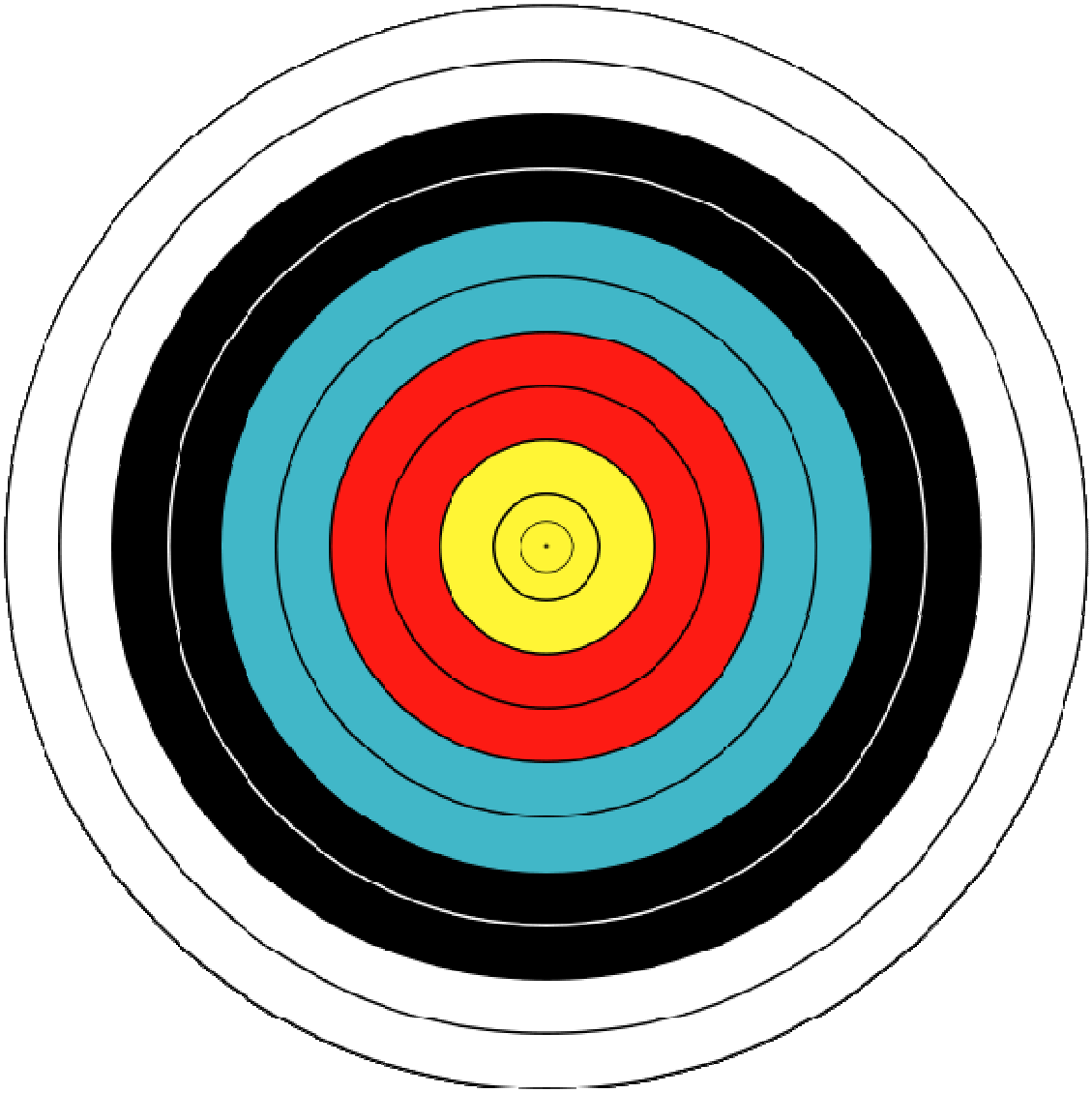

Liver

http://en.wikipedia.org/wiki/File:Archery_Target_80cm.svg

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Insulin

http://en.wikipedia.org/wiki/File:Llave_bronce.jpg

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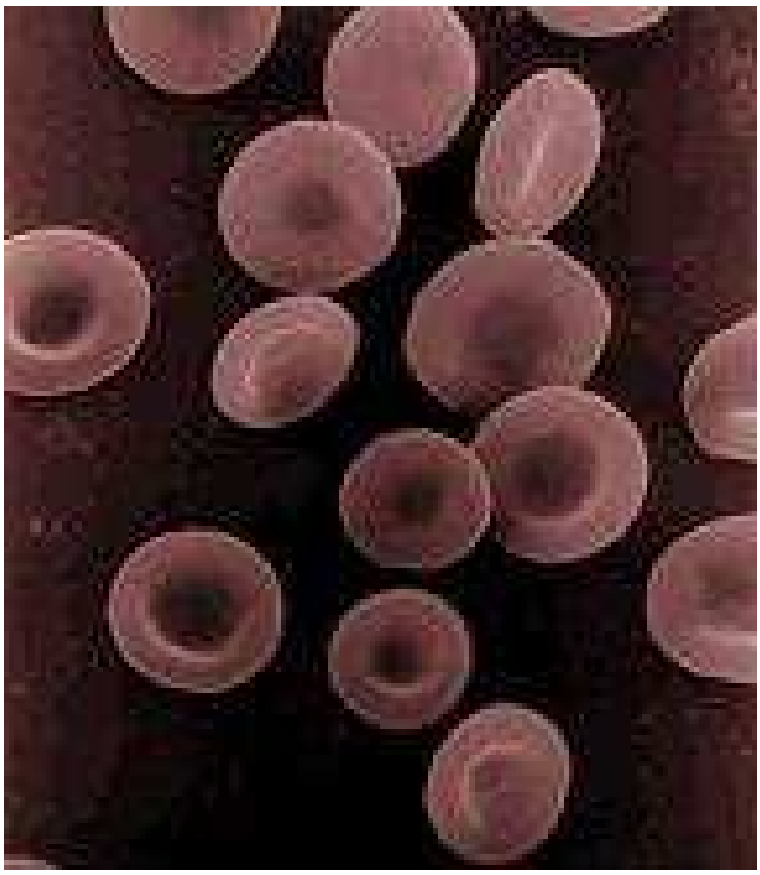

Circulatory System

http://en.wikipedia.org/wiki/File:Redbloodcells.jpg

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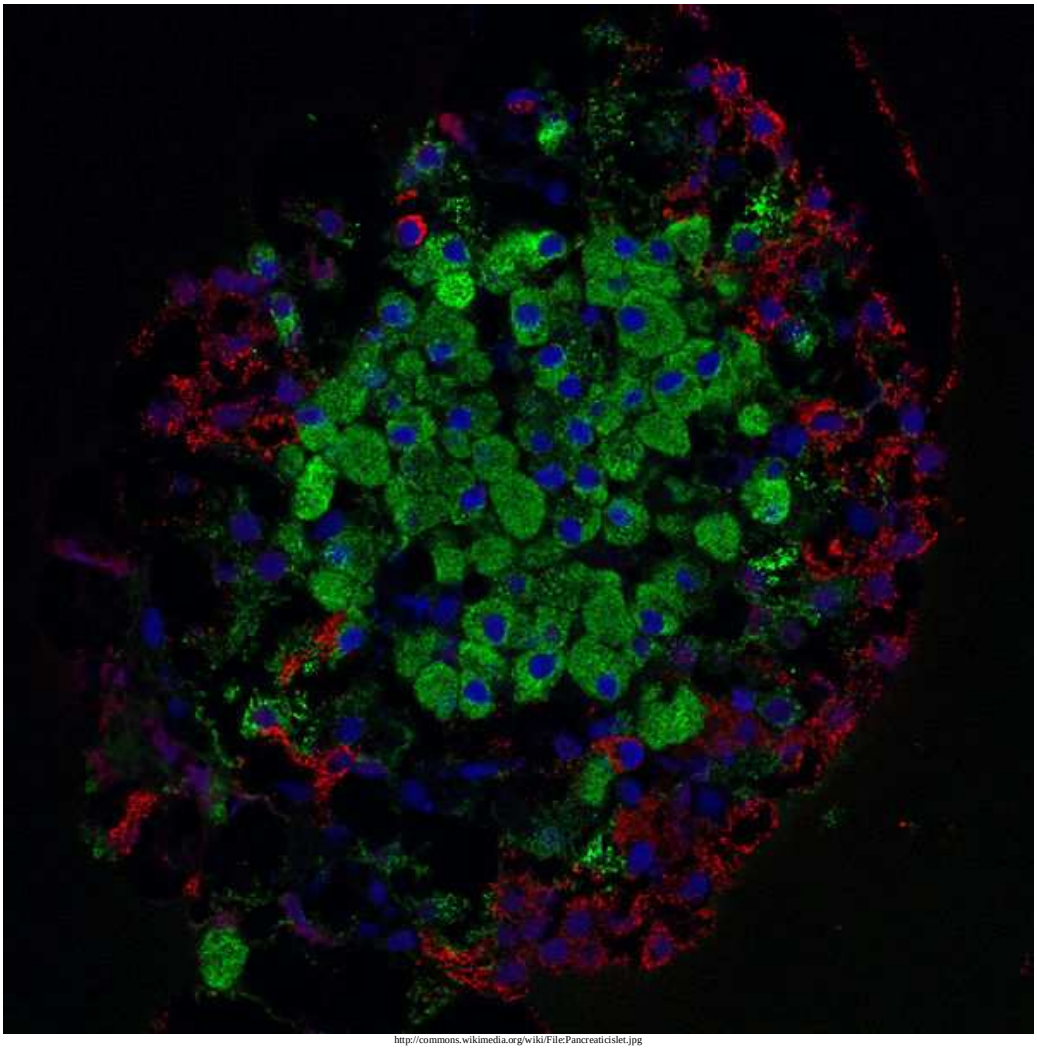

http://commons.wikimedia.org/wiki/File:Pancreaticislet.jpg

Beta cells

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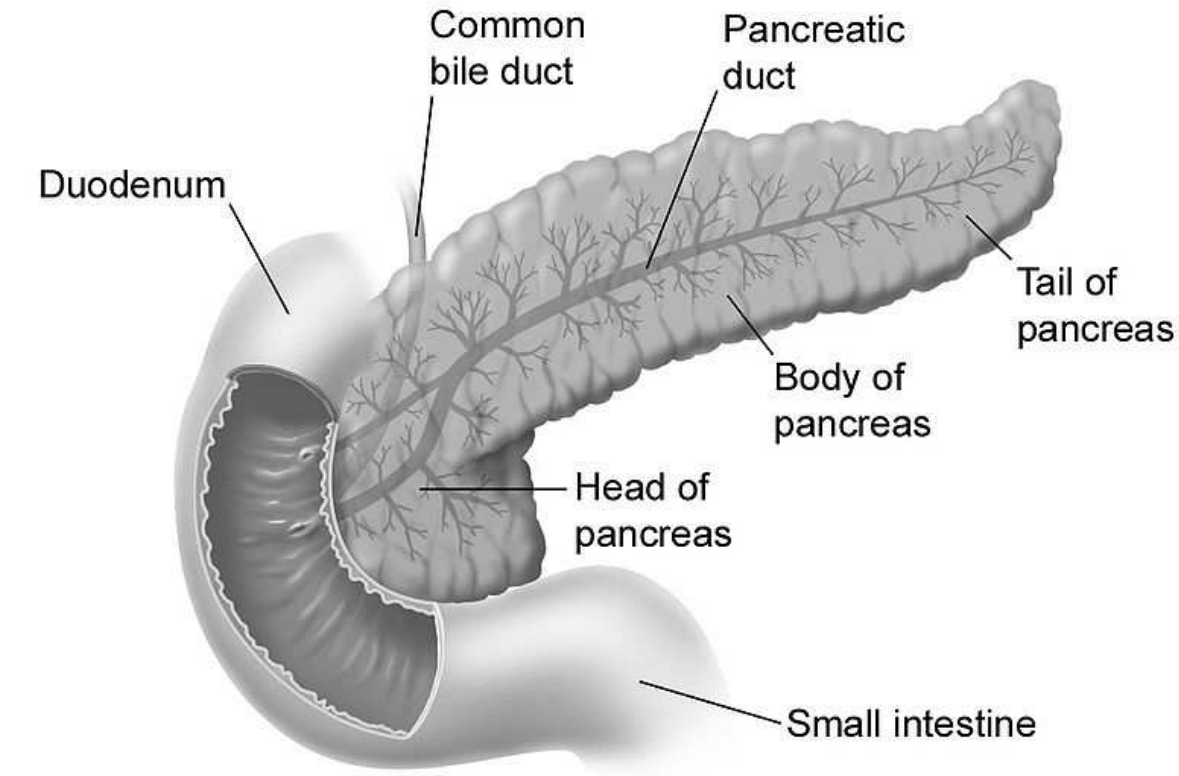

National Cancer Institute

http://en.wikipedia.org/wiki/File:Duodenumandpancreas.jpg

Pancreas

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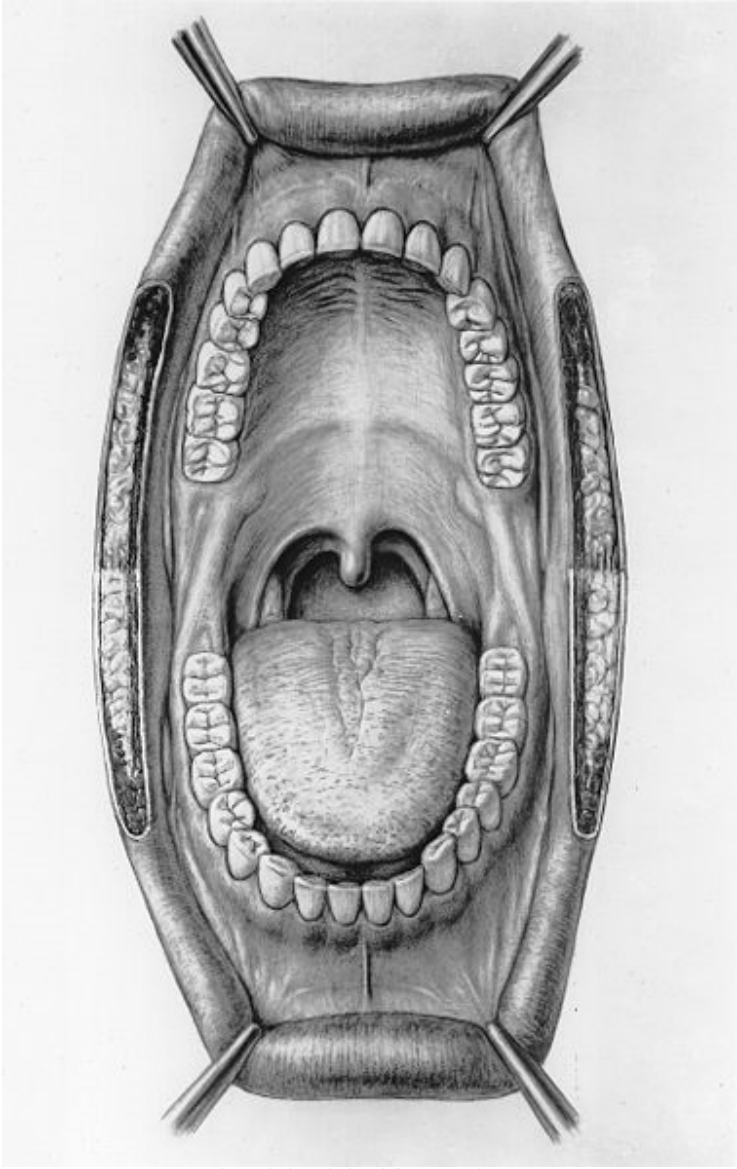

http://en.wikipedia.org/wiki/File:Mouth_illustration-Otis,_Archives.jpg

Mouth

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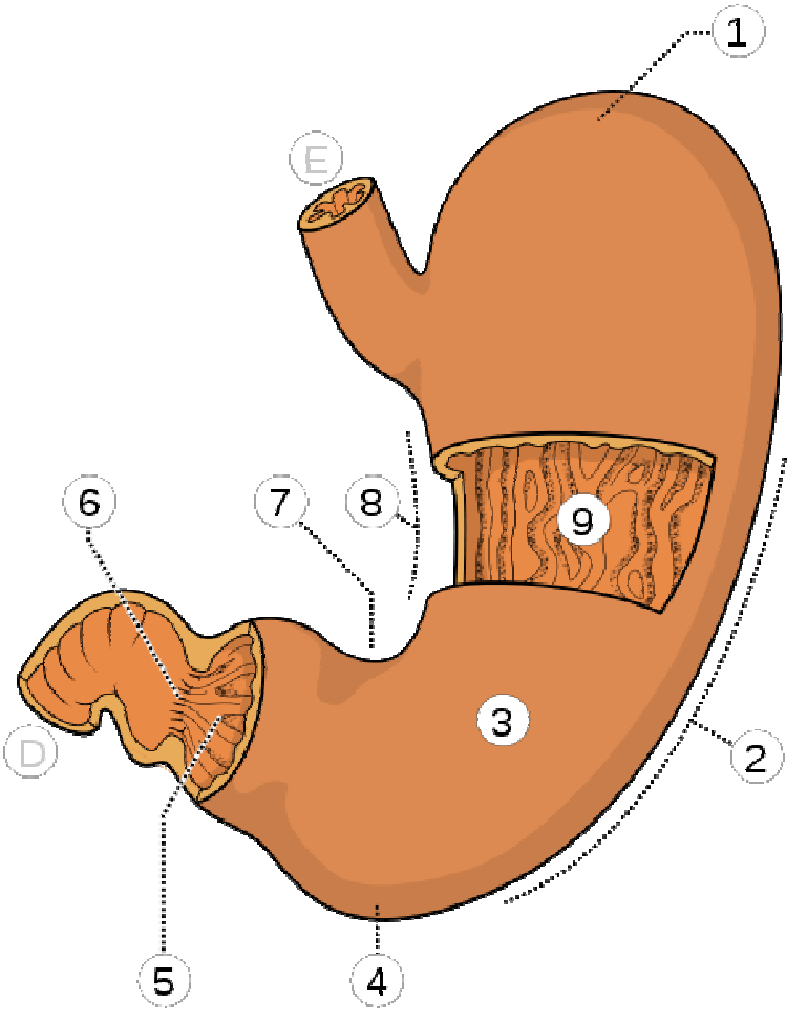

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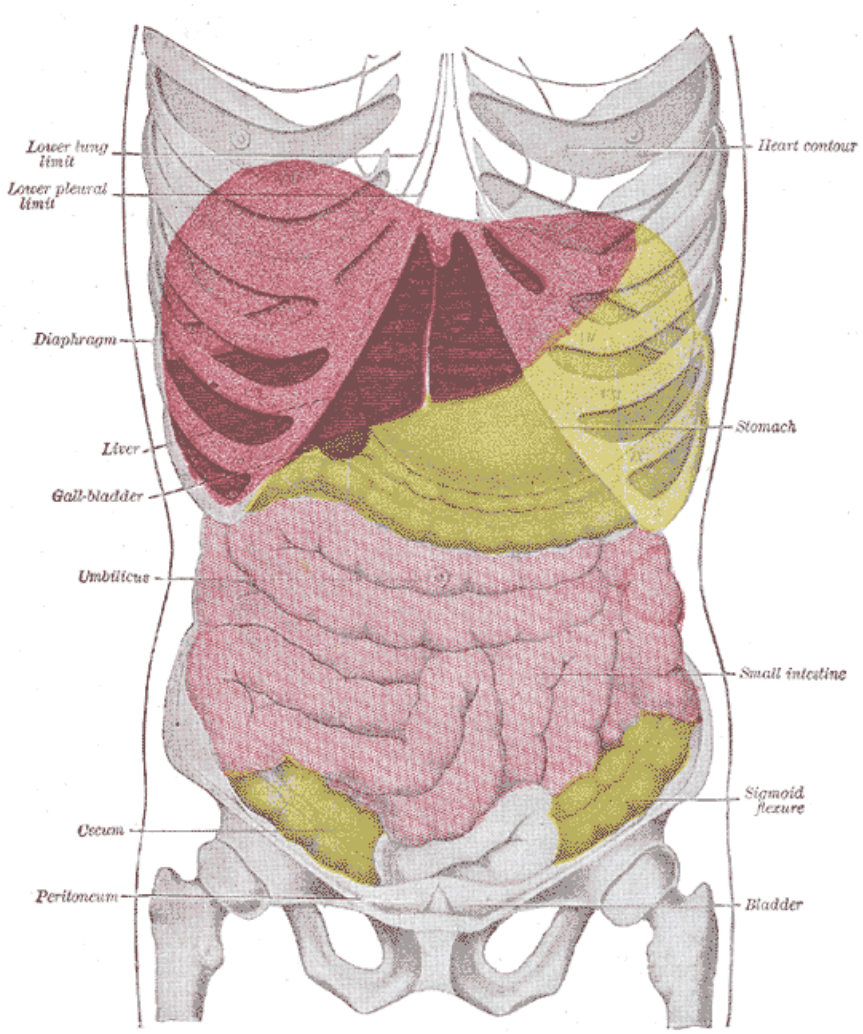
Stomach



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Small Intestine

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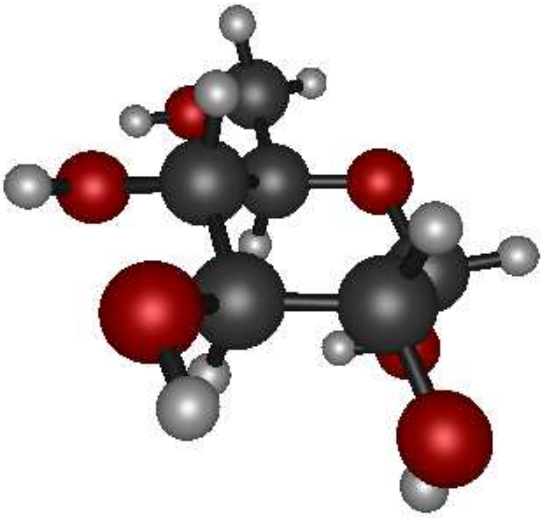

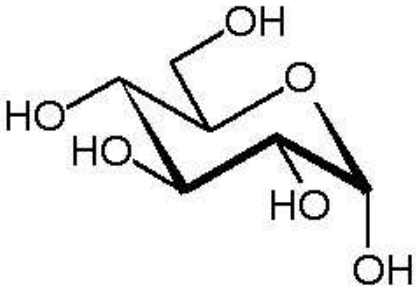

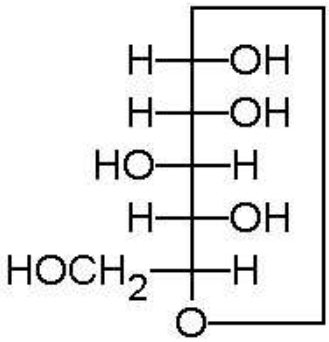

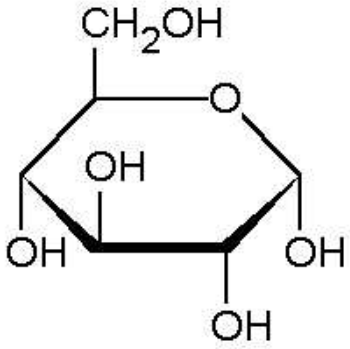

http://commons.wikimedia.org/wiki/File:Alpha-D-Glucose.png

Glucose

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