Active Transport Essay, Research Paper

Since the cell membrane is somewhat permeable to sodium ions, simple diffusion would result in a net movement of

sodium ions into the cell, until the concentrations on the two sides of the membrane became equal. Sodium actually

does diffuse into the cell rather freely, but as fast as it does so, the cell actively pumps it out again, against the

concentration difference.

The mechanism by which the cell pumps the sodium ions out is called active transport. Active transport requires the

expenditure of energy for the work done by the cell in moving molecules against a concentration gradient. Active

transport enables a cell to maintain a lower concentration of sodium inside the cell, and also enables a cell to

accumulate certain nutrient inside the cell at concentrations much higher than the extracellular concentrations.

The exact mechanism of active transport is not known. It has been proposed that a carrier molecule is involved,

which reacts chemically with the molecule that is to be actively transported. This forms a compound which is

soluble in the lipid portion of the membrane and the carrier compound then moves through the membrane against

the concentration gradient to the other side. The transported molecule is then released, and the carrier molecule

diffuses back to the other side of the membrane where it picks up another molecule. This process requires energy,

since work must done in transporting the molecule against a diffusion gradient. The energy is supplied in the form of

ATP.

The carrier molecules are thought to be integral proteins; proteins which span the plasma membrane. These proteins

are specific for the molecules they transport.

Chemiosmosis

Populating the inner membrane of the mitochondrion are many copies of a protein complex called an ATP synthase,

the enzyme that actually makes ATP! It works like an ion pump running in reverse. In the reverse of that process, an

ATP synthase uses the energy of an existing ion gradient to power ATP synthesis. The ion gradient that drives

oxidative phosphorylation is a proton (hydrogen ion) gradient; that is, the power source for the ATP syntheses is a

difference in the concentration of H+ on opposite sides of the inner mitochondrial membrane. We can also think of

this gradient as a difference in pH, since pH is a measure of H+ concentration.

The function of the electron transport chain is to generate and maintain an H+ gradient. The chain is an energy

converter that uses the exergonic flow of electrons to pump H+ across the membrane, from the matrix into the

intermembrane space. The H+ leak back across the membrane, diffusing down its gradient. But the ATP synthases

are the only patches of the membrane that are freely permeable to H+. The ions pass through a channel in an ATP

synthase, and the complex of proteins functions as a mill that harnesses the exergonic flow of H ‘ to drive the

phosphorylation of ATP Thus, an H+ gradient couples the redox reactions of the electron transport chain to ATP

synthesis. This coupling mechanism for oxidative phosphorylation is called chemiosmosis, a term that highlights the

relationship between chemical reactions and transport across the membrane. We have previously used the word

osmosis in discussing water transport, but here the word refers to the pushing of H+ across a membra!

ne.

Certain members of the electron transport chain must accept and release protons (H+) along with electrons,

while other carriers transport only electrons. Therefore, at certain steps along the chain, electron transfers cause H+

to be taken up and released back into he surrounding solution. The electron carriers are spatially arranged in the

membrane in such a way that H+ is accepted from the mitochondrial matrix and deposited – the intermembrane

space. The H+ gradient that results is referred to as a proton-motive force, emphasizing the capacity of the gradient

to perform work. The force drives H+ back across the membrane through the

specific H+ channels provided by ATP synthase complexes. How the ATP synthase uses the downhill H+ current to

attach inorganic phosphate to ADP is not yet known. The hydrogen ions may participate directly in the reaction, or

they may induce a conformation change of the ATP synthase that facilitates phosphorylation. Research has revealed

the general mechanism of energy coupling by chemiosmosis, but many details of the process are still uncertain. The

key feature of chemiosmosis is: It is an energy-coupling mechanism that uses exergonic redox reactions to store

energy in the form of an H+ gradient, which then drives other kinds of work, including ATP synthesis.

Chemiosmosis is not unique to mitochondria. Chloroplasts also use the mechanism to generate ATP during

photosynthesis; the main difference is that light drives electrons along an electron transport chain. Bacteria, which

lack both mitochondria and chloroplasts , generate H + gradients across their plasma membranes. They!

then tap the proton-motive force to make ATP to pump nutrients and waste products across the membrane, and even

to move by rotating their flagella.

Fermentation

How can food be oxidized without oxygen? Remember, oxidation refers to the loss of electrons to any electron

acceptor, not just to oxygen. Glycolysis oxidizes glucose to two molecules of pyruvate. The oxidizing agent of

glycolysis is NAD+, not oxygen. The oxidation of glucose is exergonic, and glycolysis uses some of the energy

made available to produce two ATPs (net) by substrate-level phosphorylation. If oxygen is present, then additional

ATP is made by oxidative phosphorylation when NADH passes electrons removed from glucose to the electron

transport chain. But glycolysis generates two ATPs whether oxygen is present or not?that is, whether conditions

are aerobic or anaerobic.

Anaerobic catabolism of organic nutrients can occur by fermentation. Fermentation can generate ATP by substrate

level phosphorylation, as long as there is a sufficient supply of NAD+ to accept electrons during the oxidation step

of glycolysis. Without some mechanism to recycle NAD+ from NADH, glycolysis would soon deplete the cell’s

pool of NAD+ and shut itself down for lack of an oxidizing agent. Under aerobic conditions, NAD+ is recycled

productively from NADH by the transfer of electrons to the electron transport chain. The anaerobic alternative is to

transfer electrons from NADH to pyruvate, the end product of glycolysis.

Fermentation consists of gIycolysis plus reactions that regenerate NAD+ by transferring electrons from NADH to

pyruvate or derivatives of pyruvate. There are many types of fermentation, differing in the waste products formed

from pyruvate. Two common types are alcohol fermentation and lactic acid fermentation.

In alcohol fermentation, pyruvate is converted to ethanol, or ethyl alcohol, in two steps. The first step releases

carbon dioxide from the pyruvate, which is converted to the two-carbon compound acetaldehyde. In the second step,

acetaldehyde is reduced by NADH to ethyl alcohol. This regenerates the supply of NAD+ needed for glycolysis.

Alcohol fermentation by yeast, a fungus, is used in brewing and wine making. Many bacteria also carry out alcohol

fermentation under anaerobic conditions. During lactic acid fermentation pyruvate is reduced directly by NADH to

form lactate as a waste product, with no release of CO2. (Lactate is the ionized form of lactic acid.) Lactic acid

fermentation by certain fungi and bacteria is used in the dairy industry to make cheese and yogurt. Acetone and

methyl alcohol are among the by-products of other types of microbial fermentation that are commercially important.

Human muscle cells make ATP by lactic acid fermentation when oxygen is scarce. This occurs during the early

stages of strenuous exercise, when sugar catabolism for ATP production outpaces the muscle’s supply of oxygen

from the blood. Under these conditions, the cells switch from aerobic respiration to fermentation. The lactate that

accumulates as a waste product may cause muscle fatigue and pain, but it is gradually carried away by the blood to

the liver. Lactate is converted back to pyruvate by the liver cells.