

# **APPENDIX B**

## **STSE**

### **Science-Technology-Society and the Environment**

### **Important Note**

These STSE modules are intended for teacher reference. Each is designed to target specific outcomes within Biology 2201.

# Classification by Application of Modern Technologies

## Outcomes:

1. Explain how scientific knowledge evolves as new evidence comes to light and as laws and theories are tested and subsequently restricted, revised, or replaced. (115-7)
2. Analyze and describe examples where scientific understanding was enhanced or revised as a result of the invention of a technology. (116-2)
3. Construct arguments to support a decision or judgement, using examples and evidence and recognizing various perspectives. (118-6)
4. Identify new questions or problems that arise from what was learned. (214-17)
5. Use organisms found in a local or regional ecosystem to demonstrate an understanding of the fundamental principles of taxonomy. (316-5)

## Introduction

New and Modern classification techniques have provide important diagnostic tools in the classification of organisms. The unique chemical nature of DNA can be used to identify individual organisms and/or to classify organisms. It provides a tool that can confirm relationships between individuals and also provide a means to identify a species using only the smallest fragment of biological material. All multicellular organisms have this unique fingerprint. There are many possible applications of DNA analysis. Relationships and identification using DNA evidence is widely used in court rooms to convict perpetrators of crime as well to acquit those who are wrongly convicted. Through a mapping of the unique chemical nature of the DNA molecule biologists can attain valuable information to further enhance their work. As methods of DNA analysis become more refined and utilized, the science of classification is improved. The following examples illustrate some of the possibilities of these techniques and how they help science.

## Fish Forensics

While on a normal patrol of the Flemish Cap a Canadian Coast Guard helicopter spots a Foreign trawler. When the pilot radios in the location and name of the vessel she finds that the vessel has a quota for pollack, yet the area where the vessel is sited is far from the grounds on which pollack would be caught. Yielding to her suspicions, the pilot has a support vessel pursue the trawler and detain it.

Imagine that you are the DFO (Department of Fisheries and Ocean) Scientist assigned to the case. You have strong reason to believe that the fish caught by the trawler is Atlantic Cod, yet the crew maintains that the filleted and salted fish are Pollack. How could you possibly prove that the fish is Atlantic Cod? Visually examining the flesh of the fish which has been filleted, iced, and/or salted would not aid in the identification due to the similar appearance pollack has to cod in texture, color, and smell. The answer lies in using DNA analysis.

The identity of the species of fish that has been caught, and processed can be difficult to determine. Questions may arise as to the origin of a commercial fish product, for example, whether the catch in a boat's hold has been properly reported, or whether

the label on a commercial product is accurate. Although physical identification is difficult or impossible once skin and scales are gone, the fish DNA survives processing in sufficient quantities to provide a reliable test.

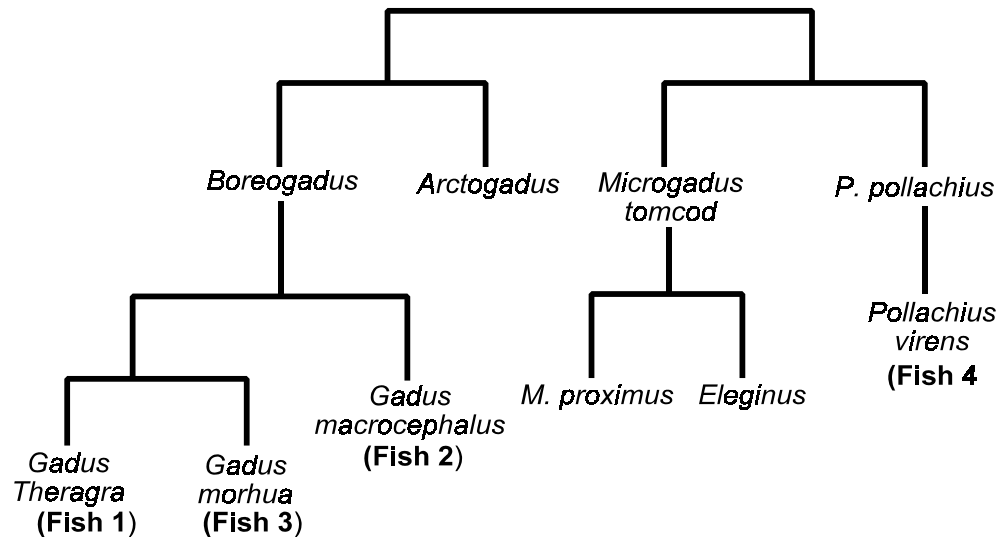


Figure 1: Comparison of DNA for known genetic species

In the test shown above, the identity of four salt-cured fish was questioned. DNA from each was **amplified** (copied), **sequenced** (coded), and compared to a DNA data base of known cod, pollock, and hake species. The analysis produces a "family tree", which shows that each fish came from a different commercial species: walleye or Alaska pollock or *Pollachius virens* (Fish 4), Atlantic cod or *Gadus morhua* (Fish 3), Pacific cod or *Gadus macrocephalus* (Fish 2), and pollock/saithe or *Gadus theragra* (Fish 1). Similar tests can be used to differentiate many species of fish. If a sample of fish is found to contain similar DNA to a known species, then it can be concluded that the sample would be the same species.

In order to compare genetic material, the actual sequence of bases must be determined in each sample. This analysis can be done through the use of gel electrophoresis. When the actual sequence of nitrogenous bases is determined a direct comparison can be made between, not only species, but also between the individuals. The closer the sequences

are to each other the more closely related the individuals.

The samples taken are often small, therefore, the amount of viable genetic material is often limited. To overcome this problem it is necessary to amplify or copy the DNA material. Older technologies (recombinant technologies) were capable of doing this, but it was time consuming. The modern means of amplifying and copying DNA is known as **Polymerase Chain Reaction (PCR)**. PCR can amplify DNA of any origin (virus, bacteria, plant, or human) hundreds of millions of times in a matter of hours, a task that would have required several days with recombinant technology. PCR is especially valuable because the reaction is highly specific, easily automated, and capable of amplifying minute amounts of sample. For these reasons, PCR has had a major impact on clinical medicine, genetic disease diagnostics, forensic science, and evolutionary biology. A diagrammatic representation of the PCR process is found in figure 2.

## DNA Amplification Using Polymerase Chain Reaction

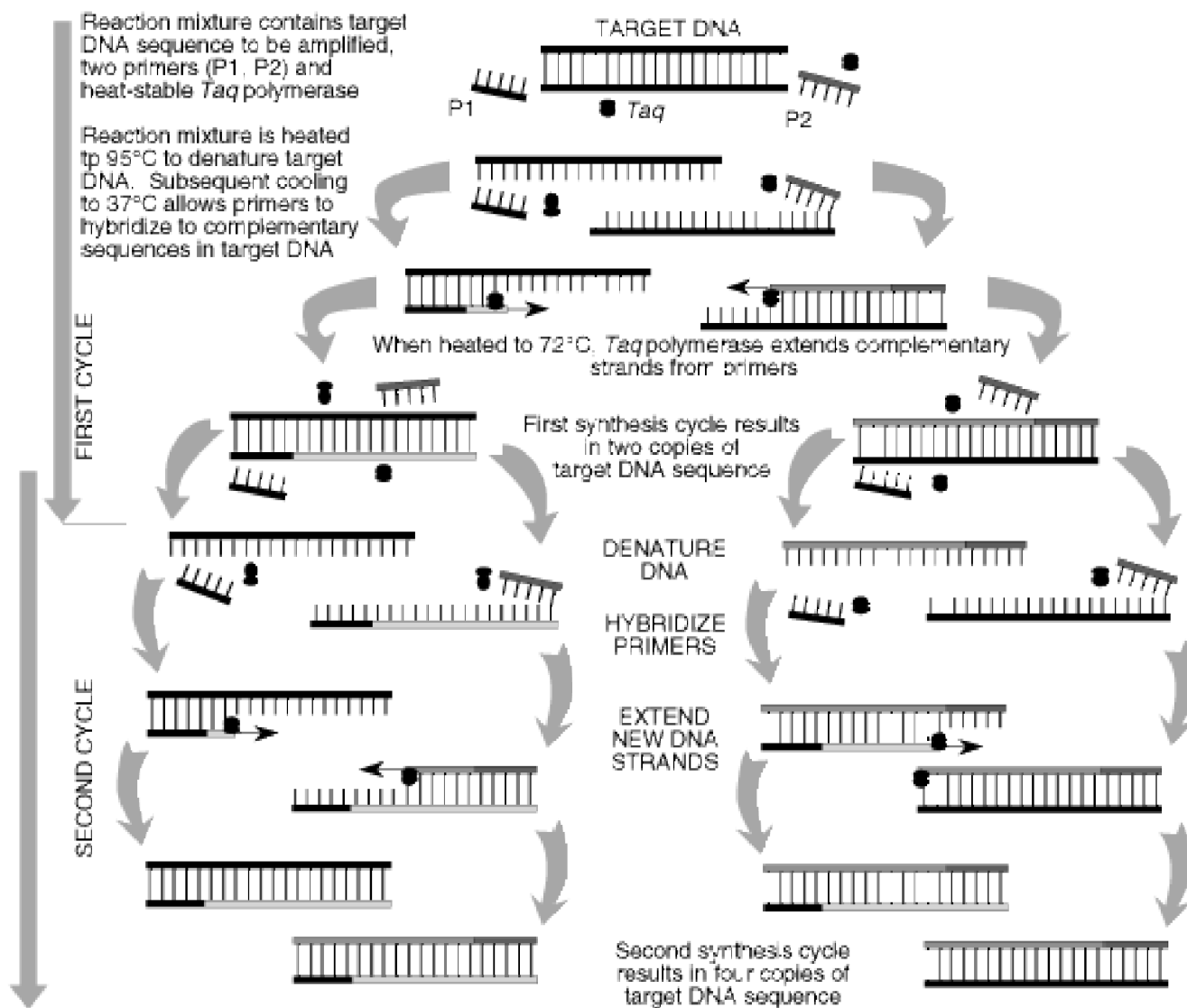


Figure 2: PCR Reaction

### The Fortune Bay "Sea Monster"

In the summer of 2001 there was a fascinating story that came from the small outpost town of St. Bernard's. Washed up on shore was an unknown creature that local residents and scientists could not visually identify. Reports were issued that describe the large creature as having fur. The description of a

large marine creature with fur started many rumors of a washed up "Sea Monster". A picture of the "sea-monster" is found at the end of this section. Genetic testing using PCR, and subsequent sequencing revealed that the "sea-monster" was in fact a badly decomposed sperm whale. As for the fur, it was actually badly decomposed fatty tissue. The following is a news release that was issued

shortly after the DNA analysis was completed.

St. John's, Newfoundland, 16 August 2001 - DNA testing has identified the “sea monster” that washed ashore at St. Bernard's, Fortune Bay, as the remnant of a sperm whale (*Physeter catodon*).

Based on material provided by Dr. Garry Stenson, of the Department of Fisheries and Oceans in St. John's, scientists at the Genetics, Evolution, and Molecular Systematics Laboratory in the Department of Biology at Memorial University of Newfoundland (Dr. Steve Carr, Dr. Dawn Marshall, Ms. Kim Johnstone, and Ms. Lori Pynn) performed a forensic DNA test to determine species origin. The analysis compared the DNA sequence of the creature's NADH2 gene ( a specific genetic marker) with that of homologous DNA from a variety of large marine species, including sharks and whales. Comparison with this database gave an almost perfect match with a sperm whale. The few observed differences are consistent with ordinary genetic variation expected among individuals within species.

The test involves a “DNA xeroxing” procedure called the polymerase chain reaction, which generates a large number of copies from a single original gene. The sequence of the gene can then be determined on an automated DNA sequencer. This type of DNA test is particularly useful in cases like the sea monster, which involve material in a poor state of preservation or of questionable origin. The identification was done as part of an ongoing collaboration between DFO and Memorial scientists to study the genetics and genomics of marine organisms.



**Figure 3:** The “Fortune Bay Sea Monster”

The DNA analysis technique described in the article is identical to the one used in our hypothetical case of Foreign over fishing. Careful examination of a

minimal amount of genetic material enables scientists to determine organisms that otherwise would be impossible to identify.

## Stock Structure in Atlantic Cod

DNA classification techniques can also be used to help make important commercial fish management decisions. Setting inshore and offshore quotas is very difficult when it is unknown if fish migrate between these two regions. This could be more easily determined if the fish could be examined to check for distinct breeding units, which can be quite significant as it pertains to setting quotas. Knowing whether the fish move between the regions would have a significant impact on quotas set by DFO.

Determining if distinct breeding exist would indicate whether fish migrate. If the fish populations were separate breeding stocks then their DNA would be different. This would mean that quotas for both could be separately established. It is widely known that present stocks of inshore cod are high, while offshore stocks are still very low. Many inshore fisherman often argue that the inshore fishery should be reopened on a larger commercial basis. DFO scientists are hesitant about this because they see a possibility of the inshore fish being used to replenish the depleted offshore stocks.

The Genetics, Evolution, and Molecular Systematics Laboratory at Memorial University has pioneered the application of DNA analysis techniques to study the natural populations of marine organisms. In particular, direct analysis of DNA sequences via the polymerase chain reaction (PCR) technology has been developed as a tool to investigate several fishery management questions. One in particular, is whether distinct breeding units exist between the inshore and offshore regions.

## Conclusion

The science of classification has progressed greatly with the development of new DNA analysis technologies. These technologies have empowered biologists with an ability to gather much more information about individual organisms and their relationships to other species using small amounts of

genetic material. Identification and subsequent classification of organisms creates evolutionary links between known and unknown species. For example, evolutionary links between humans are being uncovered by the Human Genome Project. Methods and technologies that help scientists classify and organize information enhances our ability to understand the world around us, i.e., it improves science.

## Questions

1. How could the information gathered through genetic analysis be applied to Fisheries management practices?
2. During a routine check on an offshore trawler DFO officials discover a large supply of what they believe to be frozen cod fillets. The crew has no licence for the species but maintain that the fish is pollack for which they had a quota. Discuss how the situation could be resolved.
3. What is the significance to the Inshore fishery of the province if it can be determined that the Offshore and Inshore populations of Cod are genetically distinct?
4. There have been suggestions by some that the Beothuk Indians were amalgamated into the population of early Newfoundland. How could the techniques of Molecular (DNA) classification be used to confirm or deny this suggestion? Would the conclusions reached by this method be a valid one?
5. Area quota systems are used to effectively manage big game populations. This involves managing each area as separate “stocks”. How could the science of DNA classification be used to more effectively define the boundaries that determine the areas? Why would this be (or not be) a practical means to divide the areas?

## References

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- [http://www.mun.ca/biology/scarr/WSN\\_talk.htm](http://www.mun.ca/biology/scarr/WSN_talk.htm)
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- Carr et al. 2002. The Biological Bulletin 202: 1-5



# The Problem of Kidney and Urologic Disease

## Outcomes:

1. Analyze why and how a particular technology was developed and improved over time. (115-5)
2. Compare human kidney systems and kidney dialysis systems to interpret and explain their structure and dynamics. (116-7)
3. Debate the merits of funding research into organ transplant therapy. (117-4)
4. Identify multiple perspectives that influence a science-related decision or issue. (215-4)
5. Identify, in general terms the impact of kidney disease on the homeostasis within an organism. (317-4)
6. Describe disorders linked to the excretory system and their effect on the homeostasis of the system and the organism as a whole.
7. Analyze and describe kidney dialysis and kidney transplant as ways of treating renal failure based on scientific understanding. (116-4)

## Introduction

Every year thousands of Canadians are diagnosed with some form of renal disease. Kidney disease usually progresses silently, often destroying most of the kidney function before causing any symptoms. For this reason, people at risk of developing kidney disease should be evaluated regularly. For many of those afflicted, the necessity of maintaining a homeostatic balance within their bodies forces them to undergo a procedure known as kidney dialysis. Unfortunately for many, kidney dialysis is a temporary solution, eventually they will need a kidney transplant.

This STSE module will explore the impact of renal disease on the human system and describe the seriousness of this situation for people afflicted by kidney disease. The number of Canadians over 65 with kidney failure has more than doubled in the last decade according to the Canadian Institute for Health Information. From 1990 to the end of 1999, the number of these people who developed

kidney failure and needed dialysis or a transplant soared 132 percent. During that same period, new cases in all age groups across Canada rose 73 percent. Due to this dramatic increase, this disease and its treatments are becoming a serious concern for all Canadians.

The treatment of kidney disease has come a long way over the past 30 years.

- 30 years ago - kidney failure had little hope of survival and thousands of Canadians suffered from disorders such as, kidney stones and bladder cancer.
- 20 years ago - dialysis patients spent up to 36 hours per week connected to a machine and half of kidney transplants were successful.
- 10 years ago - new dialysis treatments reduce patient time 12 hours per week.

In the future, genetic discoveries may help prevent some forms of hereditary kidney disease. Kidney transplants may become 100% successful! Dialysis and transplantation may no longer be necessary for many forms of kidney disease since more effective treatments could be discovered.

## Why are the kidneys important?

The kidneys are important because of their three essential functions:

1. Kidneys regulate water: The body must contain the right amount of water. The kidneys remove excess water from the body or retain water when the body needs more.
2. Kidneys remove wastes: Many chemicals in the blood and body must be kept at the correct concentration for the body to function properly.
3. Kidneys produce hormones: Hormones circulate in the bloodstream and regulate functions such as blood pressure, the making of red blood cells, and the uptake of calcium from the small intestine.

The kidneys are designed and placed within the body so that they can effectively remove the by-products of metabolism. (See Figure 1).

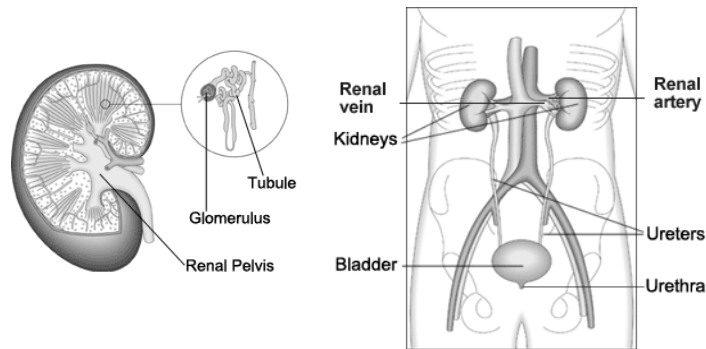


Figure 1: Location and Internal Structure of the Kidney in the Body

## Warning Signs of Kidney Disease

Sometimes even people with serious kidney disease may not have any symptoms. That is why a blood or urine tests are necessary to check for kidney problems. Possible symptoms are:

- Frequently passing urine at night
- Hypertension
- Passing less urine or difficulty passing urine
- Puffiness of the eyes, hands and feet
- Passage of cloudy or tea-colored urine
- Persistent generalized itching

A medical assessment, however, is required to determine kidney problems.

## Treatments for Kidney Disease

### 1. Diet Control

A diet for people with kidney disease helps make up for what poorly functioning kidneys are unable to

do. When the kidneys are damaged, they cannot filter the blood, therefore substances can build-up to harmful levels. This build-up can damage other organs of the body and cause problems. Changing a person's diet may minimize this toxic build-up. This diet should limit:

1. protein, a nutrient containing nitrogen
2. fluid
3. potassium, a nutrient important for muscle functioning
4. sodium, a part of salt
5. phosphorus, a mineral

Unfortunately, it is not easy to design a "diet for kidney disease." People with kidney disease are at risk for vitamin deficiencies and anemia, and their bodies may not be able to make muscle tissue and bones as usual. The extra fluid and sodium present in the blood stream can lead to high blood pressure. Hormonal changes due to the lack of filtration by the kidneys can cause cholesterol and other fats in the blood to become high. A diet for kidney disease, therefore is a very personalized diet. The degree to which each nutrient needs to be restricted varies from individual to individual. A registered dietitian is needed to instruct the patient on their specific diet. Frequent blood tests are necessary to show which nutrients need to be limited.

The diet must include the minimum amount of protein needed to provide the essential amino acids needed by the body. The amount of protein needed depends on the person's weight. Protein by-products are filtered by healthy kidneys for toxic substances. Usually, people with kidney disease are advised to get their protein from animal sources since animal proteins contain all of the essential amino acids. This allows those with kidney disease to eat a small amount of protein but still get all of their essential amino acids.

The allowable amount of sodium is usually 1,000 to 3,000 milligrams daily for people with kidney disease. This usually means limiting table salt, as well as processed, canned and convenience foods. Fruits,

vegetables and dairy products are also limited because they are high in potassium. Restricting the amount of meat and milk eaten helps to control the amount of phosphorus, saturated fat and cholesterol in the diet. Due to the diet restrictions, people with kidney disease must; include a lot of starch to provide enough calories to prevent weight loss and take supplements of vitamins (iron and calcium). This level of dietary control is difficult to maintain.

## 2. *Kidney Dialysis*

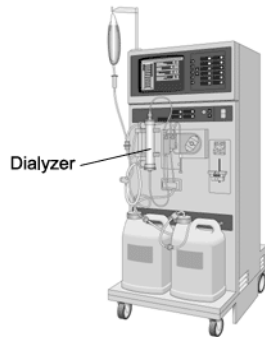
**Dialysis** is a procedure that cleans and filters the blood when the kidneys are not functioning properly. It is a treatment for people in the later stage of **chronic renal insufficiency** (kidney failure). Sometimes dialysis is a temporary treatment. However, when the loss of kidney function is permanent (as in end-stage kidney failure), the patient must continue to have dialysis on a regular basis. This treatment cleans the blood and removes wastes and excess water from the body. Dialysis keeps a person with kidney failure alive, without it people with this condition would die. The only other treatment for kidney failure is a kidney transplant.

There are two types of dialysis: **hemodialysis** and **peritoneal dialysis**. In hemodialysis, the blood is passed through an artificial kidney machine. Peritoneal dialysis uses a filtration process similar to hemodialysis, but the blood is filtered inside the body rather than in a machine. Both types of dialysis require surgery to prepare the person's body.

### *Hemodialysis*

**Hemodialysis** means "cleaning the blood"-and that is exactly what this treatment does. Blood is circulated through a machine which contains a **dialyzer** (also called an artificial kidney). An illustration of the machine is found below (See Figure 4). The dialyzer has two spaces separated by a thin membrane. Blood passes on one side of the membrane and dialysis fluid passes on the other. The wastes and excess water pass from the blood through

the membrane into the dialysis fluid which is then discarded. The cleaned blood is returned to the patient's bloodstream.



**Figure 4:** Hemodialysis Machine

The patient can be attached to the dialysis machine in different ways. The most common method of providing permanent access to the bloodstream for hemodialysis is an internal fistula in the patient's arm. This involves having an artery and a vein connected surgically. When they are joined, the stronger blood flow from the artery causes the vein to become larger. Needles can be inserted in the enlarged vein to connect the patient to the dialysis machine.

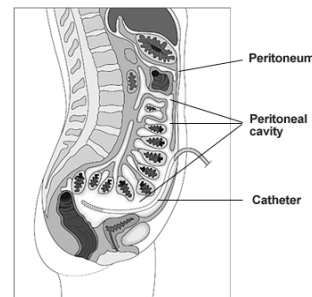
Inserting an **internal graft** is another way to provide access to the bloodstream. In this procedure an artery is surgically connected to a vein with a short piece of special tubing placed under the skin. Needles can be then inserted in this graft.

Each hemodialysis treatment normally takes three to five hours, and usually three treatments a week are required. Only a small amount of the blood is out of the body at one time. Therefore the blood must circulate through the machine many times before it is cleaned.

### *Peritoneal Dialysis*

The inside of the abdomen is called the peritoneal cavity and it is lined with a thin membrane called the peritoneum. This membrane surrounds the

intestines and other internal organs. Peritoneal dialysis is also called **continuous peritoneal dialysis (CPD)**. In CPD the patient always has dialysis fluid in the peritoneal cavity, so the blood is constantly being cleaned. The fluid is changed at regular intervals throughout the day using a catheter (See Figure 5).



**Figure 5:** Peritoneal Cavity with Catheter Insertion

Excess water and wastes pass from the blood through the peritoneum into the dialysis fluid. This fluid is then drained from the body and discarded. In most cases this treatment can be performed, at home or at work without assistance.

A tube called a **catheter**, made of soft, nonirritating plastic, is inserted in the patient's abdomen below the navel, and stays there as long as the patient is using this type of dialysis. The catheter may be inserted using local anesthetic, or in the operating room, depending on what is best for the patient. The dialysis fluid flows into, and is drained out of, the peritoneal cavity through this special tube.

Peritoneal dialysis is not painful, however, care must be taken to avoid infection.

Whatever type, usually, repeated dialysis sessions are needed for survival. Peritoneal dialysis is done at home. After each time the equipment is used, it must be carefully cleaned to prevent infection. Hemodialysis usually requires a person to go to a dialysis center three times a week. People often feel tired, weak, and even confused after dialysis sessions until the body adjusts to the procedure.

### 3. *Kidney transplants*

A kidney transplant is a surgical procedure in which a healthy, donated kidney is transplanted into the patient's body. A successful transplant will allow the patient to return to a healthier lifestyle and will free them from dialysis treatments.

*Who is a candidate for the procedure?*

It is the treatment of choice for people with chronic renal insufficiency who are considered suitable candidates for a transplant.

There are a few conditions that would rule out a transplant entirely. These include:

1. cancer within the past 5 years as the risk of developing complications following the transplant increase dramatically
2. infections such as tuberculosis or osteomyelitis, (an infection of the bones). This renders the persons immune system in a weakened state and may complicate the acceptance of the donated organ.
3. severe heart, lung, or liver problems as the person would be unable to physically handle the procedure.

Once a person is deemed suitable as a transplant candidate, a donor must be found. The best situation is for the donor kidney to come from a living family member as the likelihood of a genetic match is much greater and therefore the likelihood of rejection is considerably less.

There are two types of kidney transplants: a **living donor transplant** and a **cadaveric transplant**.

#### *Living Donor Transplant*

In a living donor transplant, a kidney from a donor, usually a blood relative, is transplanted into the patients body. The donor's blood group and tissue type must be compatible with the patients, and extensive medical tests would be done to determine

the health of the donor. People who donate a kidney can live a normal life with one kidney and there are few risks to the healthy donors. For this type of transplant, there is a shorter waiting period and the transplant operation is planned at a time convenient for both patient and donor. Living donor transplants have a 90 to 95% success rate. That means that after one year, 90 to 95 of every 100 transplanted kidneys are still working.

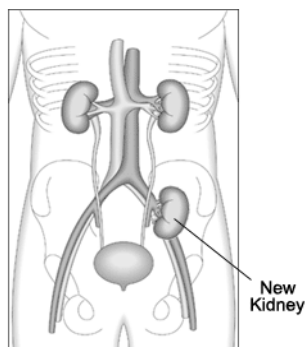
#### *Cadaveric Transplant*

In a cadaveric transplant a healthy kidney from someone who has died suddenly is transplanted into the patients body. Before a cadaveric donor's organs can be transplanted, a series of medical tests is done to determine if the organs are healthy. In addition, the family of the donor must consent to organ donation.

After the patient has a series of tests, they are put on a transplant waiting list until a kidney is found that is compatible with their body. The length of time patients wait is hard to predict because it depends on how hard they are to match and how many kidneys become available. Unfortunately, the waiting time for a cadaveric organ transplant is getting longer. Cadaveric transplants have an 80 to 85% success rate.

*What happens during transplant?*

The kidney transplant operation usually takes two to four hours. The new kidney and ureter (the tube through which the urine flows into the bladder) are placed in the lower abdomen near the groin as illustrated in Figure 3. They are surgically attached to the blood vessels and bladder. The old kidneys are not removed unless they are so large there is no room for the new kidney, or they are chronically infected.



**Figure 3:** Location Transplanted Kidney

*What happens right after the procedure?*

The recipient of the new organ needs to take drugs to suppress their immune system and prevent their body from rejecting the new kidney. These are started either immediately before, or during the transplant procedure. Even with many precautions and a healthy donor kidney some complications are possible. These may include:

1. Infection, which happens in roughly 25% of transplant recipients.
2. Problems with the blood vessel connections between the donor kidney and the recipient's pelvic vessels.
3. Clot in the blood supply to the kidney. If this happens, the kidney may die.
4. Narrowing of the artery within the kidney (called Transplant Renal Artery Stenosis). This limits blood flow to the kidney and makes it difficult to keep blood pressure under control. Usually, the narrowed segment can be expanded using **angioplasty** (a small balloon that is inflated in the narrow section).
5. Leaky ureter connections to the bladder. This problem is treated by inserting a stent. A stent is a very thin, straw-like tube that provides a kind of scaffolding around which tissues can heal.
6. Kidney rejection. The body's normal immune response to the new kidney is to reject it. Drugs to suppress the immune system prevent rejection in most cases.

Kidney transplantation usually has very positive results. Recipients live longer, healthier lives than is possible with dialysis treatments. There is a greater short-term risk of death associated with the surgery, however, this risk is outweighed by the long-term effects of continuous dialysis. Depending on the source and quality of the donor kidney, 80% to 95% of the time there is a successful outcome for a kidney transplant and it can last an average of 8 to 25 years.

Outcomes for living kidney donors are excellent. The risk of death from kidney donation is less than 4 in 10,000, and there are almost no long-term risks. Living kidney donors do not need to undergo any special medical testing, maintain any special diet, or take any medications as a result of kidney donation.

## Conclusion

The impact of Renal Disease on both the patient and their families is great. The treatments; dialysis, transplant or diet modification, can greatly affect the way that the afflicted person is able to carry out their daily lives. Diet modification would be the least intrusive, however, is usually only successful for the early stages of kidney disease. Dialysis provides a short term measure of treatment for more severe kidney problems, but over time may not be sufficient to treat the condition. Kidney transplantation, the third and most obtrusive treatment, is a major surgery and like all major surgeries there are the possible complications. At present, there is research being conducted into which method of treating kidney disease is most effective - this cost money. With a limited pool of research dollars available, where should the money be spent?

## Questions

1. Define the following terms:
  - (i) Peritoneal cavity
  - (ii) Hemodialysis
  - (iii) Catheter
  - (iv) Peritoneal dialysis
  - (v) Stent
2. Describe some of the problems commonly associated with both Kidney dialysis and Kidney transplant.
3. With a limited pool of research dollars available for the conduction of Medical Research where should the money be primarily spent? Support your answer.
4. Why is it so important that a kidney patient control their diet?
5. In a recent Episode of a popular TV drama series a mother suffering from kidney disease had their daughter artificially inseminated so as to bear a child that would provide a donor kidney. The daughter was inseminated through the use of the

fathers sperm. Does this means of acquiring a donor kidney constitute a viable option both medically and ethically?

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<http://www.kidney.ca/programmes-eng.htm>

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[http://www.vanhosp.bc.ca/html/patient\\_outpatient\\_edu\\_renal.html](http://www.vanhosp.bc.ca/html/patient_outpatient_edu_renal.html)





# What is Cancer?

## Outcomes:

1. Analyze why and how a particular technology was developed and improved over time.(115-5)
2. Analyze and describe examples where technologies were developed based on scientific understanding. (116-4)
3. Debate the merits of funding specific scientific or technological endeavors and not others. (117-4)
4. Explain how different plant and animal systems, help maintain homeostasis (317-1)
8. Identify in general terms the impact of viral, bacterial, genetic, and environmental diseases on the homeostasis of an organism. (317-4)

## Introduction

There are many things that influence the ways that living organisms are able to effectively cope with changes in the environment. Using various feedback mechanisms, organisms are able to respond to changes, although there are situations that arise that makes this maintenance difficult. One such difficulty is the development of disease. The following STSE Module will outline the impact that cancer has on the body's ability to maintain this dynamic balance. This Module outlines the impact that one type of cancer, Hodgkin's disease, has on the body's ability to maintain its' dynamic balance.

## What is Cancer?

One of the most frightening diagnoses that a person can be told by their physician is that they have cancer. Cancer is not just one disease but rather a group of diseases. All forms of cancer cause cells in the body to change and grow out of control. Most types of cancer cells form a lump or mass called a **tumor**. Cells from the tumor can break away and travel to other parts of the body where they can continue to grow. This spreading process is called a metastasis. When cancer spreads, it is named after the part of the body where it started. For example, if

breast cancer spreads to the lungs, it is still called breast cancer, not lung cancer.

Tumors which are cancerous are referred to as **malignant**, while those tumors that are not cancerous are referred to as **benign**. Benign tumors do not grow and spread the way malignant tumors do, and are usually not a threat to life as they lack the ability to metastasize and interfere with surrounding tissue. Not all cancers form tumors, a few cancers, such as blood cancers (leukemia), interfere with the production of cells throughout the human system. Other examples of this type of cancer include cancers of the lymphatic system such as Hodgkin's and Non Hodgkin's lymphoma.

One in three Canadians will be diagnosed with cancer in their lifetime. Cancer is now the second leading cause of death in Canada and given current trends, its incidence is expected to increase by 70 per cent by the year 2015. The good news is, with improved screening tests, availability of comprehensive information, and better treatments, more than half of all people with cancer will survive the disease.

## What Is Hodgkin's Disease?

In Canada it is difficult to hear the term Hodgkin's Disease without thinking of one of the greatest hockey players in the world - Mario Lemieux. He is an example that a diagnosis of a cancer is nowhere near as devastating as it once was. He was treated for Hodgkin's Disease and returned to a productive career as one of the NHL's elite players.

Hodgkin's disease (also called Hodgkin's lymphoma) is a type of cancer that starts in lymphatic tissue. Lymphatic tissue includes the lymph nodes and other organs that are part of the body's system that forms blood and protects against germs. Lymph nodes are small, bean-shaped organs found in many places throughout the body. The lymph nodes make and store white blood cells that fight infection.

Lymph vessels, narrow tubes similar to blood vessels, connect the lymph nodes and carry a clear fluid that contains the white blood cells. The lymphatic system also includes the spleen, bone marrow, and thymus.

Due to the presence of lymphatic tissue in many parts of the body, Hodgkin's disease can start almost anywhere, and can spread through the lymphatic vessels. If it gets into the blood vessels, it can potentially spread to almost any place in the body.

Hodgkin's disease is named after Dr. Thomas Hodgkin who first recognized it in 1832. Hodgkin's Disease is identifiable through the presence of what are known as Reed Sternberg Cells. The following figure shows what these cells look like.

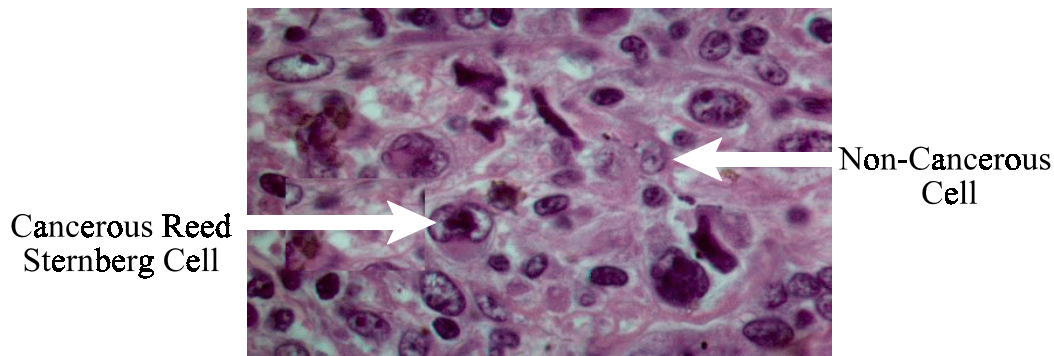


Figure 1: Reed Sternberg Cell as identified through the Arrow.

The nodules contain numerous cells (mostly lymphocytes) and two distinct types of malignant cells. One of these malignant cells, the Reed-Sternberg cell, is large, frequently binuclear or **multinuclear** (containing more than one nucleus).

## Prevalence of Hodgkin's Disease?

The National Cancer Institute of Canada reported that in 2001 there were 810 new cases of Hodgkin's disease in this country, 120 of these cases succumbed to the disease. Both children and adults can get

Hodgkin's disease but it is most commonly found in two age groups: early adulthood (ages 15-40), and late adulthood (after age 55). Due to improved treatment, death rates have decreased by over half since the early 1970's. Today the Death-to-Case Ratio is listed at 0.15 for all patients.

The 1-year relative survival rate after treatment is 93%; the 5-year and 10-year rates are 82% and 72% respectively. At 15 years, the overall survival rate is 63%. It should be noted that these survival rates are based on treatment regimens that were in place 15 years ago. The survival rate refers to the percent of

people with Hodgkin's disease who live at least that many years after their cancer is diagnosed.

## What Causes Hodgkin's Disease? Can It Be Prevented?

A **risk factor** is anything that increases a person's chance of getting a disease such as cancer. Different cancers have different risk factors. Scientists have identified a few risk factors for Hodgkin's disease. These include a past history of mononucleosis, and a reduced immune system, such as people who have had organ transplants or those with AIDS. If someone does have one or more risk factors for Hodgkin's disease, it is impossible to know how much each risk factor contributed to causing the cancer. Unlike many other types of cancer, Hodgkin's disease does not seem to be caused by problems with a person's genes, their diet or environmental factors. Since the cause(s) of Hodgkin's disease is unknown, it is not possible at this time to list preventive measures.

## How Is Hodgkin's Disease Diagnosed?

### *Symptoms of Hodgkin's Disease*

There are no early screening tests for Hodgkin's disease, and often people with the disease have no symptoms. Symptoms of the disease include enlarged, painless lymph nodes. In most people, especially children, enlarged lymph nodes are caused by an infection or other illness and not cancer. An early sign of Hodgkin's disease, therefore is a person has lymph nodes over an inch in size and no recent infection.

The disease causes the lymphatic tissue to become enlarged and press on nearby structures. The swelling of lymph nodes inside the chest, creates pressure on the windpipe, which can result in coughing or shortness of breath. Other symptoms include fever, drenching night sweats, or weight loss. Many of these symptoms resemble what one would

expect to see if one were suffering from a common flu or cold. The key to detection, is that persons having these symptoms and 'if they persist' should seek medical advice from their physician.

### *Tests to Diagnose Hodgkin's Disease*

If a person potentially has Hodgkin's disease, certain information must be gathered. The first would be a complete medical history and thorough physical exam to determine whether there is an infection. During the exam, the doctor will pay particular attention to the lymph nodes. Since it is common for people, especially children, to have swollen lymph nodes, the doctor will probably prescribe antibiotics initially to see if the lymph nodes shrink, if they do not, more testing is required.

The only way to conclusively determine whether a person has Hodgkin's disease is to perform a **biopsy** (examine a tissue sample under the microscope). Some biopsies involve cutting through the skin to remove an entire node or a small part of a large tumor. In another type, the doctor uses a thin needle to remove a small amount of fluid and tiny bits of tissue from the tumor. A doctor with special training in blood and lymphoid tissue disease examines all biopsy samples under a microscope and looks for the Reed Sternberg Cells. Sometimes the first biopsy does not provide a definite answer and more are needed.

## What are the Stages of Hodgkin's Disease?

Staging is the process of determining how far the cancer has spread. This is very important because the treatment and the outlook for recovery depend on the stage of the cancer. The staging system for Hodgkin's disease is called the Ann Arbor Staging Classification. This system has four stages, labeled I through IV. In general, the lower the number, the less the cancer has spread. A higher number, such as Stage IV, means a more serious cancer.

Clinical staging consists of taking the patient's medical history, doing a physical exam, and then doing several kinds of imaging studies. Imaging studies such as CT (**computed tomography**) and MRI (**magnetic resonance imaging**) are used to create detailed pictures that show the size and shape of lumps or tumors that might be cancerous.

For many people, the results of the clinical staging will determine the plan for treatment. Other cases, however, require pathological staging. In this process, a laparotomy is performed to check inside the abdomen for any organs that contain cancer. Small pieces of tissue are removed and looked at under a microscope to see if Hodgkin's disease is present.

## How Is Hodgkin's Disease Treated?

After Hodgkin's disease is staged, the doctor will discuss treatment choices with the patient. It is important to take time and think about all the treatment choices. The two main methods of treating Hodgkin's disease are chemotherapy, and radiation therapy. These treatments are used independently or together depending on a number of factors. If the disease is isolated to one specific area (Stage 1) often only radiation therapy is used. If the disease is spread over multiple areas then chemotherapy is used. Combinations of these treatments would be determined by the examining specialist.

### *Chemotherapy*

Chemotherapy is the use of drugs to kill cancer cells. Usually the drugs are given orally or intravenously and subsequently enter the bloodstream, and are carried throughout the body. Drug cocktails are often given with each drug capable of acting on certain characteristics of the cancer cells.

Combining drugs produces a more effective treatment. The drug cocktails work to interfere with the cells ability to reproduce. Therefore the cancer cells live out their normal course of life and die.

Without the ability to reproduce the cancer cells are unable to spread and if the drugs are effective the cancer will be eliminated from the person's body.

Unfortunately the drugs that kill cancer cells also damage normal cells - especially those that rapidly reproduce such as the blood cells (Red Blood Cells, White Blood Cells, Platelets, etc.), epithelial tissue, hair follicles, and reproductive cells. The side effects caused by this damage, depend on the type and dose of drugs used and the length of time they are taken, but they can include hair loss, mouth sores, increased chance of infection, easy bruising or bleeding, fatigue, loss of appetite, nausea, and vomiting. These side effects are temporary and go away after treatment is finished. If the patient has severe side effects, the cancer care team can suggest ways to ease their impact. For example, drugs can be given to prevent or reduce nausea and vomiting.

Some patients, however are at risk of developing more severe long term side effects, even after chemotherapy is finished. These can affect a person's heart, lungs, growth, and ability to reproduce. There is also a risk of developing a secondary type of cancer. The risk of these long term effects have greatly diminished as treatment programs have improved.

### *Radiation Therapy (Radiotherapy)*

Unlike Chemotherapy, Radiation therapy involves a very localized attack on a diseased area. The chemotherapy provides a more systemic approach whereas the Radiotherapy involves a direct attack.

When radiation therapy is given, it usually involves a focused beam of x-rays, from a machine outside the body, known as external beam radiation. In Canada, Radiotherapy is given by a machine called a Linear Accelerator. It converts household electrical current to 6,000,000 - 21,000,000 electron volts and converts it to X-rays. The x-rays are then refined to only a single energy and are focused on a specific target point. The beam can be changed in size and shape (but not intensity) to tailor the treatment for

any one person. The duration of the treatment determines the total dose that is delivered.

Radiation therapy can produce some serious side effects including damage to nearby healthy tissue skin changes (similar to sunburn), tiredness, upset stomach, and loose bowels. To reduce the risk of side effects, technicians are careful to deliver the exact dose needed in an accurate beam hitting only the cancer.

### *Bone Marrow Transplantation*

Sometimes Hodgkin's disease stops responding to the standard treatments of chemotherapy and radiation therapy. In these cases, bone marrow transplants might be performed.

In one procedure, the patient's own bone marrow is removed and stored. Then very high doses of chemotherapy (with or without radiation therapy) are given to the patient to kill the cancer. These high doses will also destroy bone marrow. After the treatment, the stored marrow is transplanted back to the patient through a vein. The bone marrow cells enter the bloodstream and return to the bone, replacing the marrow and making new red and white blood cells.

In another type of procedure, called **peripheral blood stem cell transplant** (PBSCT), a machine removes the patient's blood a little at a time. Only the stem cells (immature cells from which all blood cells develop) are removed. These are stored to be reintroduced at a later date. The rest of the blood is returned to the body. This process usually takes a few hours. The stem cells are frozen until they are returned to the patient after treatment is finished.

## **Conclusion**

The treatment of Hodgkin's Disease and all cancers has improved greatly over time. The diagnosis of

the cancer is not as devastating as it once was. There have been considerable improvements in all aspects of the treatment of the disease. Presently the likelihood of a complete cure for those afflicted with the Hodgkin's Disease is at greater than 80%. With further research this statistic will undoubtedly improve.

## **Questions**

1. What are the symptoms of a person diagnosed with Hodgkin's Disease? How are these symptoms related to other body systems?
2. Explain the reasons for chemotherapy causing side effects for the patient such as hair loss.
3. Why would a bone marrow transplant provide a course of treatment for a patient afflicted with Hodgkin's Disease?
4. Children tend to have an even higher success rate in dealing with this disease? Why would this be so?
5. Define the following terms:
  - (i) malignant and benign tumors
  - (ii) metastasis
  - (iii) Biopsy
  - (iv) Staging
  - (v) Chemotherapy
  - (vi) Radiotherapy

### *Extension/Research*

1. When a patient is undergoing chemotherapy blood tests are regularly conducted. One of the blood components that are closely monitored is the neutrophil count. What are the role of the neutrophils? Why would treatment be delayed if the neutrophil count drops?
2. If you had a million dollars to donate to cancer research into which treatment (Chemotherapy, Radiation, or Bone Marrow transplantation) would you want the money put into and why?

3. Hodgkin's Disease was one of the first cancers that was described. Some of the early treatments used a noxious chemical called Nitrogen Mustard. Why was this used and what were the potential side effects of using this chemical?

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