Welcome to the Parasitology Section of this course. This section will cover the human disease caused by parasites. In this lecture we cover a general overview of parasitology and some of the human diseases caused by a type of parasites known as Trematodes.

In this section we will cover many things amongst which are the Global impact of the parasitic diseases along with some basics of parasitology. Most of you have probably learnt some things about parasites in some of your Biology classes. We discuss mainly those parasitic diseases in detail that are of major human health importance or are currently a public health problem or are emerging and have the potential to be a public health problem. The parasitic diseases will be discussed in such a way as to cover the introduction of the disease, its epidemiology, disease description, treatment and prevention. Also we will cover aspects of the disease that could make it an Emerging infectious disease.

The section will have reading quiz that will have questions based on the reading material in the text. The block exam on parasites will be based on the lecture material and the reading material. It is essential to study the lifecycles of the parasites thoroughly as these are the main things of importance when studying parasitology. Some of the questions will be case studies that will be followed by questions to determine the causative organism, treatment, epidemiology and preventive measures.
Slide 4

Learning Objectives (Overall)

• Recognize the importance of parasitic diseases as a component of global infectious disease burden
• Understand how environmental, social, biological, and other factors lead to transmission of parasitic diseases
• Identify regions of the world where certain parasites are endemic or emerging
• Differentiate between classes of parasites that are presented
• Identify sources of infection and types of hosts that can act in spreading disease
• Know control and prevention measures for parasites discussed
• Know methods of diagnosis and current treatments
• Parasite and Disease names - common and Genus and species (Latin names)
• Understand life cycles of parasites

Let's talk about some of the learning objectives of the class. In this class you will learn about importance of parasitic diseases as a global public health issue; the environmental, social, biological and other factors that affect the transmission of parasitic diseases; identify regions of the world that are endemic for certain parasitic diseases; Recognize the sources of infection and the various vertebrate and invertebrates that act as host and or reservoirs for parasites. Know the control measures and methods of control for the parasitic diseases as well as methods for their diagnosis and treatment. Most crucially you will learn the parasite and disease names and understand the life cycles of parasites.

Slide 5

Life Cycles- very important to know

• They will tell you critical information, including
  – What are the hosts?
  – Where is it found (geographic region)?
  – How is transmitted?
  – Where does it go to/through in the host?
  – How does it come out?
  – How do you diagnose it?
  – Infectious, developmental stages

It is extremely important to know the lifecycles of the parasites. They contain important information about the mode of transmission, infective forms, definitive hosts, intermediate hosts, developmental forms of the parasites and environmental factors that are necessary for the completion of the lifecycle of a parasite and what specimen to be used to diagnose the parasitic infestation.

Slide 6

Infectious Diseases: Global Mortality

• Infectious diseases constitute a significant part of global mortality each year
• Annual deaths from infectious diseases ~16,000,000
deadly / year
  - World Health Organization
  - United Nations
  - United States
  - United States

This slide from 2004 by WHO shows the relative rank of infectious parasitic diseases as the cause of mortality globally. The major cause in this remain malaria. It is important to understand that although in the developed world lifestyle diseases remain the major cause of mortality, most of the global population resides in the developing world where the parasitic infections remain endemic causing mortality.
The parasitic disease responsible for most deaths is Malaria. According to the latest WHO estimates, there were about 219 million cases of malaria in 2010 and an estimated 660,000 deaths. Africa is the most affected continent about 90% of all malaria deaths occur there. As seen in the map the main regions of the world endemic for malaria are Africa, South Asia, Southeast Asia and the Central America with the Amazonian rain forest.

This is a slide with some older data and shows the significance of the parasitic diseases in terms of the annual mortality rates in humans. As we can see from the tables malaria remains the parasitic disease with the most number of deaths annually. The parasitic diseases mainly occur in countries where the food and sanitation along with the vector control measures are not efficient to break the life cycle and or cycle of transmission of the parasite infective forms to humans. As we will see in detail in subsequent lectures, knowing the life cycle of the parasite is an important tool for control strategies for these parasitic diseases. The slide taken together with the previous slide indicates the importance of malaria as the most significant parasitic disease of public health importance with respect of mortality.

It is essential to know why the parasitic diseases are important. A good way to understand this is to divide them broadly into two categories. The first group is of those that are major killers like malaria, American Trypanosomiasis also known as Chagas disease, African Trypanosomiasis or sleeping sickness, Schistosomiasis and Amebiasis. The other is comprised of those that impair the development of children and/or affect quality of life. This group includes lymphatic filariasis, geohelminthes, onchocerciasis, cysticercosis, waterborne and food borne protozoal parasites like Giardia, cutaneous Leishmaniasis and dracunculiasis or the Guinea worm.
### Human Parasitic Diseases with Major Public Health Impact

- **International**
  - Malaria
  - Schistosomiasis
  - Filariasis
  - Guinea worm disease
  - Trachoma
  - Leishmaniasis
  - Neurocysticercosis
  - Echinococcosis
  - Dracunculiasis
- **Domestic (USA)**
  - Cryptosporidiosis
  - Giardiasis
  - Neurocysticercosis
  - Toxoplasmosis
  - Trichomoniasis
  - Cyclosporiasis
  - Pneumocystis pneumonia
  - Naegleria

This slide lists out the parasitic diseases of Major Public health impact from an International and Domestic (USA) perspective. The diseases in the international list are the one should be aware of when travelling internationally and take precaution in terms of protective clothing, food and water habits and prophylactic medication e.g. malaria. Domestically the parasitic diseases of importance are generally acquired during outbreaks due to food or water contamination such as cryptosporidiosis. Sometimes recreational activities like hiking through the mountains and drinking water from streams can lead to Giardiasis. Unprotected sexual intercourse puts one at risk of Trichomoniasis and swimming in lakes exposes one to risk of infection with the brain eating amoeba – Naegleria.

### Neglected Tropical Diseases (NTDs)

- Afflictions that have burdened humanity for centuries
- Relatively unheard of in developed countries
- Cause high morbidity leading to disability, inability to work, childhood malnutrition, blindness, severe disfigurement
- Rural areas of low-income countries and fragile states
- Globally, the rural poor represent 900 million people, of which 411 million are poor livestock keepers (almost half in south Asia and one-third in sub-Saharan Africa).
- Areas where income is inversely related to burden of disease

Neglected Tropical Diseases. These are so called due to the limited focus of research and effort to control them that has led to very few drugs for their treatment unlike malaria or bacterial diseases. These have been documented in ancient medical texts and continue to be prevalent in the poor parts of the world. Generally the prevalence of these diseases is inversely proportional to the income in the affected areas. Also, most of these are associated with a social stigma because of disfigurement that can be caused by them as in cutaneous Leishmaniasis similar to leprosy. Onchocerciasis causes blindness. These diseases have a high morbidity affecting the quality of life.
This slide gives an overview of the neglected tropical diseases and gives their prevalence and areas of distribution. Note nearly all of them are prevalent in sub-Saharan Africa which is also one of the poorest regions in the world.

The slide shows the status of neglected tropical diseases and importantly it summarizes the control strategies being implemented worldwide for the control of these diseases. It would be good to pause the presentation for a minute and review this slide. It is also a good slide to quickly revise the control strategies for the different neglected tropical diseases.

Here we see the importance of the Neglected Tropical Diseases using a quantifiable unit called DALY i.e. Disability Adjusted Life Years. These combine the effect of death and disability in a population into a single comparable measure. As we see from the graph NTDs account for about 57 million DALYs lost. One sixth of the world’s population suffers from these diseases and the occurrence of conflict, war or natural disasters like floods, famines and drought only work to aggravate the situation.
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This slide shows how more than one disease exists in a given part of the world with regions of Africa and Brazil where up to 6 of these diseases can occur and indeed many time a fecal sample will reveal the ova and or cysts/trophozoites of more than one parasite. It is essential to note the absence of the neglected tropical disease in North America and how international travel exposes us to the risk of acquiring them. The travelers can then bring these back to the US and cause transmission.

This slide lists the factors that contribute to the parasitic diseases to becoming Emerging Infectious Diseases. Evolution plays a critical role for an organism to become pathogenic by introduction of existing agents, hosts or vectors to a new location and then followed by establishment and spread. For e.g. the *Aedes albopictus* mosquito is now wide-spread in the USA after hitching a ride in some tyres imported from East Asia. Human activities lead to destruction of wildlife habitats and bring man in contact with potential parasitic zoonoses otherwise restricted to wildlife. Biological, ecological, environmental factors, economic and military activities, societal factors, migration and travel – all put selective pressure on microbes. Additionally, the breakdown of public health measures in natural disasters like hurricanes or floods and earthquake. Furthermore we as yet do not have good drugs for treatment of these parasite diseases. The existing ones are inadequate and poorly tolerated or ineffective.
Climate change can and does influence the distribution and spread of infectious diseases. In this slide it is important to note that many waterborne and vector borne parasitic diseases can be affected by climate changes.

In the case of vector-borne diseases, the vector, the microbe, or both, may see increases due to rising temperature. This slide gives an overview of the vector borne diseases that can potentially see a change in terms of vector population and disease spread due to estimates and predictions of temperature rise from climate change. Noteworthy is the possible change in distribution for malaria.

Besides the aforementioned possible modes of transmission, technological advances and host diseases states can also lead to increased susceptibility to parasitic diseases. Blood transfusion can transmit Chagas diseases due to the hemoflagellate Trypanosoma cruzi present in the blood. Organ transplant can also transmit Chagas Diseases. Patients with immunocompromise such as those with AIDS are also at risk of parasitic diseases e.g. Strongyloides stercoralis infection and diarrhea.
Microbial Evolution and Adaptation

- Resistance to antibiotics and antimicrobials is at a crisis level worldwide.
- The appearance of resistant bacteria is due to adaptation and selection (i.e., Darwinian evolution), which is accelerated by misuse. Examples:
  - Prescribing antibiotics (that only work against bacteria) for viral illness (e.g., the flu or a cold)
  - Failure of patient to complete drug regimen

<table>
<thead>
<tr>
<th>Disease</th>
<th>Bacterial Disease</th>
<th>Viral Disease</th>
<th>Protozoal Disease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typhoid Fever</td>
<td>Salmonellosis</td>
<td>Hepatitis</td>
<td>Malaria</td>
</tr>
</tbody>
</table>

PHC4031. Emerging Infectious Diseases

Just as with bacterial infections drug resistance is an important problem for the management and control of parasitic infectious diseases. This is especially true for malaria where the parasite evolves to escape the immune system by antigenic modification and gains resistance to anti-malarials by making pumps that throw out the drugs before they can act.

Human Waste Disposal

The safe disposal of human excreta is central to sanitation; food and water contaminated with feces is a major cause of infectious disease.

- 2.6 billion people lack access to appropriate toilet facilities
- 200 million tons of human waste is uncollected and untreated
- In India, over 100 million households have no toilets
  - Half a million children die yearly in India due to dehydration resulting from diarrhoeal diseases
- Programs to improve sanitation are in progress in slums:
  - The Kampung Improvement Program in Indonesia
  - The Orangi Pilot Project in Karachi, Pakistan

PHC4031. Emerging Infectious Diseases

Lets look at human waste disposal. Safe disposal of human waste is of paramount importance for the control of food-borne illnesses especially those with fecal-oral transmission. Worldwide 2.6 billion people lack access to appropriate toilet facilities. About 200 million tonnes of human waste is uncollected and untreated. In India, over a 100 million households have no toilets. As a result, half a million children die annually in India due to dehydration resulting from diarrhoeal diseases. Some examples of the improving sanitation in slums are the Kampung Improvement Program in Indonesia and the Orangi Project in Karachi, Pakistan.

Clean Water

- Over 1.5 billion people worldwide lack access to clean water
- There is a strong correlation between access to safe drinking water and child health

This slide shows the worldwide distribution of safe drinking water and the under 5 child mortality rate. It is clearly evident that developed countries like the US, Sweden and New Zealand with 100% safe drinking water coverage have some of the lowest mortality for children under 5 years of age.
**Health for All**

"The highest attainable standard of health is one of the fundamental rights of every human being." — Harvard School of Public Health

- For those in the industrialized world, the past 50 years have witnessed impressive gains in healthy life expectancy
- 85% of the world’s population live in developing countries and they do not reap the full benefits of modern health care
- Those in the developing world lack
  - Decent housing
  - Clean water
  - Sanitary waste disposal
  - Appropriate nutrition
  - Education

This slide is a good summary of what the scope of global health is. Those in the developed nations do not necessarily grasp that many people in the developing world lack decent housing, safe drinking water and sanitation, appropriate nutrition and education. The lack of education and awareness of how the parasitic diseases are acquired is crucial in the prevalence and spread of parasitic diseases.

**Parasitology**

- Study of parasites, their hosts, and the relationship between them.
- Eukaryotic organisms that infect and/or cause disease in man and animals
- Parasitism, a type of symbiosis where only one member profits significantly from the association (Host+Parasite)
- More than half of all species on Earth are parasites, yet most remain unknown.
- Range from simple unicellular organisms to complex vertebrates
- Zoonotic infections

Parasitology is an old science and indeed parasites have been described since ancient times. Parasites are eukaryotic organisms that infect and cause diseases in man and animals. Parasitism is a type of symbiosis where only one member profits significantly from the association. The parasite range from unicellular organisms like protozoans to complex multicellular complex organisms like parasitic worms.

**Biological Associations**

- Symbiosis or “living together” is an association between two or more species
  - Mutualism: a condition in which both species benefit (lichens)
  - Commensalism: one species benefits but neither suffers nor is harmed (normal flora)
  - Parasitism: an association in which the parasite lives at the expense of the other species, the host (all microbial pathogens)
- Parasitism results in a constant negotiation between the parasite and its host, as each evolves in response to the other

Parasitism is a kind of a biological association in which the parasite lives at the expense of the host and can cause disease in the host. It is a kind of symbiosis, the other types of symbiosis being mutualism and commensalism.
Now we talk about the significant aspects of parasitology. The most important is the life cycle. It is necessary to understand and remember the life cycle since it not only tells you about the developmental stages of the parasite but also about the intermediate hosts, definitive hosts, reservoir hosts and paratenic hosts. Definitive hosts are ones in which the parasite undergoes sexual reproduction and it is usually a vertebrate host like humans or pigs or dogs. Intermediate hosts are usually invertebrate hosts and are the ones in which the parasite undergoes asexual reproduction. The reservoir hosts serve to host the parasite for long-term in the environment by which other hosts can acquire the parasite and cause parasite transmission. Paratenic hosts are hosts that maintain the life cycle of the parasite but are not needed for development.

Reservoirs are important for a pathogen. These are sites in the environment in which the micro-organism survives and possibly multiplies and from where it can be transmitted to susceptible individuals. Many a time the reservoir is a human. Humans can be active carriers i.e. individuals who actually have the diseases or they can be healthy carriers where they do not have the diseases. In either case they harbor the parasite and can transmit it to another individual. So if we can treat the reservoir, we can potentially eliminate the risk of transmission of microbial diseases. This is the basis of mass drug administration programs for the control of many parasitic diseases like river blindness and geo-helminths. We will cover these further in later lectures.
This slide shows some of the zoonotic diseases. Note the protozoal infections that can be transmitted by insects such as ticks and mosquitoes on the left and those that are transmitted via food and water on the right.

This slide lists the diseases transmitted by insect bites. Note that the top of this list is mainly the parasitic infections. Although not in this list, malaria is the most important vector borne parasitic disease.

The graphic gives a comparative visual of the difference in size of the different parasites.
These are the parasites that we will be covering in this course.

This is kind of a summary of helminthes. These are multicellular eukaryotic organisms and are mainly transmitted by food, water, vectors or direct contact. Most of them are prevalent in tropical countries. The worm diseases mainly affect quality of life due to debility and very rarely are fatal. In some regions of the world almost 90% of the population has some worm infestation. In the US and other temperate regions, the presence of helminthic diseases is becoming an issue of increasing concern due to immigration, travel and immune compromise due to AIDS.
Now we look at the Trematodes. The important things to know when studying about the Trematodes are the different types that cause human infection. It is essential to recognize the similarities and differences between them as well as those for Trematodes from other worm parasites. It is necessary to remember the Latin names and the names of the definitive and intermediate hosts; also, to know the geographic areas where these occur and the infective forms and diagnostic stages. Pertinently, understand why some of these are emerging infectious diseases.

These are the most widespread of the parasitic worms and they parasitize nearly all classes of vertebrates. Essentially for the Trematodes i.e. the flatworms or flukes is that they many times have 2\textsuperscript{nd} or 3\textsuperscript{rd} intermediate hosts and usually it's a mollusk like a snail, sometimes a crab and a definitive host. The infective forms for the definitive hosts and the intermediate hosts are essentially different and have different names as the parasite undergoes development when moving from one intermediate host to another and from intermediate host to the definitive host. So it is essential to know that. All flukes are hermaphrodites i.e. the individual bears both male and female reproductive organs in the same individual. Major zoonotic diseases include Schistosomes which have male and female sexes separate. Trematodes are important zoonotic diseases causing agents.
Let’s look now at the general scheme of the life cycle of a trematode. The trematode larva that hatches from an egg is called a miracidium. This then seeks out an intermediate host and enters it to form a stage called redia. Here the redia undergoes asexual reproduction to form cercariae which are released from the intermediate host. In some cases a second intermediate host is sought in others the definitive host is sought. The cercariae then enter the definitive host either through food or skin. In case of a second intermediate host, the cercariae develop into metacercariae and these then infect the definitive host. Most important to remember is that the Cercariae / metacercariae are the infective forms for the definitive host.

An estimated 750 million people are at risk of infections with foodborne trematodes, which comprise liver flukes, lung flukes and intestinal flukes. At least 56 million people suffer from one or more foodborne trematode infections worldwide according to the latest report of foodborne Trematodes by WHO in August 2012. Mainly aquatic food sources such as fish, shell-fish and plants serve as sources of infections for humans. Most of the over 70 known species of foodborne Trematodes pathogenic to man affect either the hepato-biliary system, enteric system or the pulmonary system to cause damage and illness.

This slide is from the latest update on foodborne Trematodes of public health importance by WHO in August 2012. It lists four of the commonest food borne trematode diseases and their important characteristics. We will be covering these and some others in this course.
In this lecture we will covering these four Trematodes.

**On the Menu: Lecture 1**

- Human liver flukes
  - *Fasciola hepatica*
  - *Clonorchis sinensis*
  - *Opisthorchis* spp.
- *Echinostoma* spp.

**Slide 41**

*Fasciola hepatica*

- First trematode to be identified (de Brie, 1379)
- Sheep liver fluke
- An outbreak of liver rot in Britain, which killed over 3 million sheep in 1879-80 led to elucidation of life cycle in 1881

Fasciola hepatica is an important parasite of sheep and sometimes cattle that can infect humans. It is also called the sheep liver fluke. Indeed in the late 1800s an outbreak of liver rot in sheep leading to loss of about 3 million livestock stimulated scientists to elucidate the life cycle of this parasite. The image in the right bottom corner shows an adult *F. hepatica* next to a larger species of liver fluke — *F. gigantica*.

**Slide 42**

**Fascioliasis**

- Infects between 2.5-17 million people annually (WHO) most geographically widespread FBT
- It is one of the most economically important parasitic diseases of livestock
- Source of infection: contaminated leafy plants (i.e. watercress) containing infective larvae
- *Fasciolopsis buski*: closely related, but adults live in small intestine and limited to Asian and Indian subcontinent

Fascioliasis is the disease condition caused by species of *Fasciola*, and this disease affects between 2.5-17 million people as estimated by the WHO. This makes it the most geographically spread foodborne trematodiasis. It is one of the most economically important parasitic diseases of livestock and it sometimes can cripple the industry in areas where cattle and sheep are being raised but for humans, the actual sources of infection are from contaminated leafy plants and in the bottom right you can see watercress plants and these would contain the infected larvae. The metacercaria is the stage of the larvae that encysts on the plants and this is how humans get infected. *Fasciolopsis buski* is a closely related organism to species of *Fasciola*, but those parasites actually live in the small intestine in comparison to the liver and it is limited to the Asian and Indian subcontinent. It can cause disease but is not as widely known as *F. hepatica*. 
The lifecycle of F. hepatica is shown. The schemas of lifecycles are taken from the CDC website which is very educational in terms identifying the infective and the diagnostic stages and very simplified. The infective form is the encysted metacercaria on the aquatic plants. These are ingested by humans or sheep or cattle. The parasite excysts in the duodenum and migrates in the hepatobiliary tract to become a mature adult. It then releases unembryonated eggs which are released in feces. The eggs when released in water sources embryonate and the larval stage – miracidium hatches out and seeks the intermediate host-snail. In the snail the miracidium undergoes further development through the stages of sporocyst → redia → cercaria. The cercaria are released in the water. They are free swimming and after a while encyst on water plants which are then consumed by a susceptible host and the cycle continues.

Fascioliasis is the name of the condition of infestation with the liver flukes of Fasciola or Fasciolopsis genera. These parasites have a worldwide distribution wherever there is livestock farming and human cases are increasingly reported from Europe, the Americas and Oceania. The main parasite there is Fasciola hepatica. While in Africa and Asia both F. hepatica and F. gigantica overlap. The highest prevalence has been reported from the Bolivian altiplano and has been attributed to living close with sheep and poor information and lack of awareness of disease transmission. A variety of snail species can act as intermediate hosts for F. hepatica and number of vertebrate species can act as reservoir hosts for this parasite. F. gigantica is mainly found in tropical regions such as in Africa, South and South East Asia, southern Europe and some cases have been reported in Hawaii and the former USSR.
As with all worm-induced disease, morbidity is closely linked to the intensity of the infection or worm burden.

• Acute disease (migration of the immature fluke through liver)
  – Abdominal pain, hepatomegaly (enlarged liver), fever, vomiting, diarrhea, eosinophilia (high levels of white blood cells that fight off worms)

• Chronic phase (caused by the adult fluke within the bile ducts): symptoms reflect biliary obstruction and inflammation.

• Occasionally, abnormal infections (lungs, pharyngeal mucosa, brain) can occur.

The intensity of disease is based on the number and location of the parasitic worms. Fascioliasis causes two types of disease syndromes. The Acute type is when the immature fluke migrates through the liver parenchyma causing inflammation and pain in the abdomen, nausea, vomiting, fever and diarrhea. The chronic form is caused by the adult fluke when it settles for a life in the biliary tract and cause repeated obstructive symptoms like abdominal colicky pain in the right upper quadrant. Rarely the larva migrates to aberrant sites like lungs or brain. The image shows the liver flukes in sheep liver as seen on an autopsy.

Fascioliasis is diagnosed by the identification of eggs in stool. Other test can be serologic that detect antibodies. These are useful in early stages when the eggs may be difficult to detect due to fewer eggs in stool. The treatment is with triclabendazole which is active against both immature and adult parasites. The image is of egg showing a miracidium inside with the operculum of the egg.

The Prevention and Control for Fascioliasis are based on increased awareness and education of the population at risk. Elimination of the animal sources of infections and containment by deworming of animals. The reduction of plants and molluscs by use of herbicides and molluscicides can also be employed to control fascioliasis. Importantly safe sewage disposal of human and animal waste is essential measure as well.
The next parasite we talk about is Clonorchis sinensis or the Chinese liver fluke. It was first discovered in the late 1800s. The adult worm is elongated and has an anterior terminal sucker and the ovaries and testes filling most of the body cavity. Another similar parasite called Opisthorchis viverrini also causes similar disease albeit in a different part of the world. Together they cause over 30 million infections globally. Commonest source of infection are undercooked / dried fresh water fish crustaceans. Cats and dogs and other animals that feed on offals of fresh water fish can serve as additional reservoirs.

The life cycle of Clonorchis is similar. Here the infected form is encysted metacercaria in fish flesh unlike in Fasciola where it is encysted on plant. The remainder of the life cycle is similar to that of Fasciola. Cats, dogs, pigs and several other fish eating mammals can maintain the infection.

C. sinensis is endemic in East Asia, South east Asia, especially South Korea and Viet Nam. O. viverrini is found in mainly NE Thailand, Laos and Cambodia. Drying and pickling fish do not kill the metacercaria and the export of these food items can export the parasite as well. Indeed a survey of 150 Chinese immigrants in NYC found a 26% incidence.
The main pathology due to Clonorchis and Opisthorchis is due to biliary inflammation and obstruction. Both of these parasites are associated with higher incidence of cholangiocarcinoma. 77% of cholangioma patients in Korea have documented infections with C. sinensis. C. sinensis is classified as a group 2 carcinogen. Acute phase is similar to fasciola. The diagnosis is by detection of the characteristic eggs which are smaller and have a hook at the broader abopercular end. The treatment for C. sinensis is with Praziquantel or albendazole.

For prevention and control it is crucial to thoroughly cook the fish. Also, it is important to stop the practice of fish farming using mammalian feces. The pictures show a toilet over a carp pond where the effluents from the toilet go. The lower picture show a pig enclosure next to a pond where fish are farmed. The pig fecal wastes are released into the pond. It is important to educate the people to stop such practice to break the life cycle of the parasite. Also, raw fish is a delicacy and such culinary practices help to maintain the parasite in the human host.

An emerging infectious disease is Haplorchis spp. It is found in Viet Nam and is closely related to Clonorchis. It is intestinal parasite and not liver parasite. Viet Nam has favorable snail hosts that can maintain the lifecycle of the parasite. Previously only Thailand and China were known to have this parasite, but now Haplorchis has been found in Viet Nam. Thus the globalization with movement of people and food exports can cause emergence of disease in newer places that previously did not have them.
The last parasite for this lecture is Echinostoma. It is distinguished by a terminal sucker and spines around it. In fact 'echinostoma' means 'spiny mouth'. Most important is E. ilocanum. It is caused by inadvertent consumption of snails or clams, fish with metacercaria. It causes inflammation of small intestine and is easily treated with praziquantel. In Philippines, snails are sometimes considered a delicacy. A new parasite E. malayanum was described in Philippines that was never found there before and is possibly due to snails brought in that came laden with metacercariae.

Echinostoma spp.

- At least 15 species reported in humans
- Most important species to humans is E. ilocanum
- Up to 30% prevalence in SE Asia
- Inadvertent ingestion of snails, clams, fish with metacercaria
- East Asia, Southeast Asia, India
- Inflammation of small intestine
- Rx: praziquantel
- In Philippines, sometimes snails eaten as delicacy
  - 2007 report: first ever infections of Echinostoma malayanum reported in Philippines

The life cycle of E. ilocanum is as follows: The eggs are passed in feces and maintained in the environment through intermediate snail hosts. An additional definitive host for this parasite are the water birds and that is different from Fasciola and Clonorchis fluke worms.