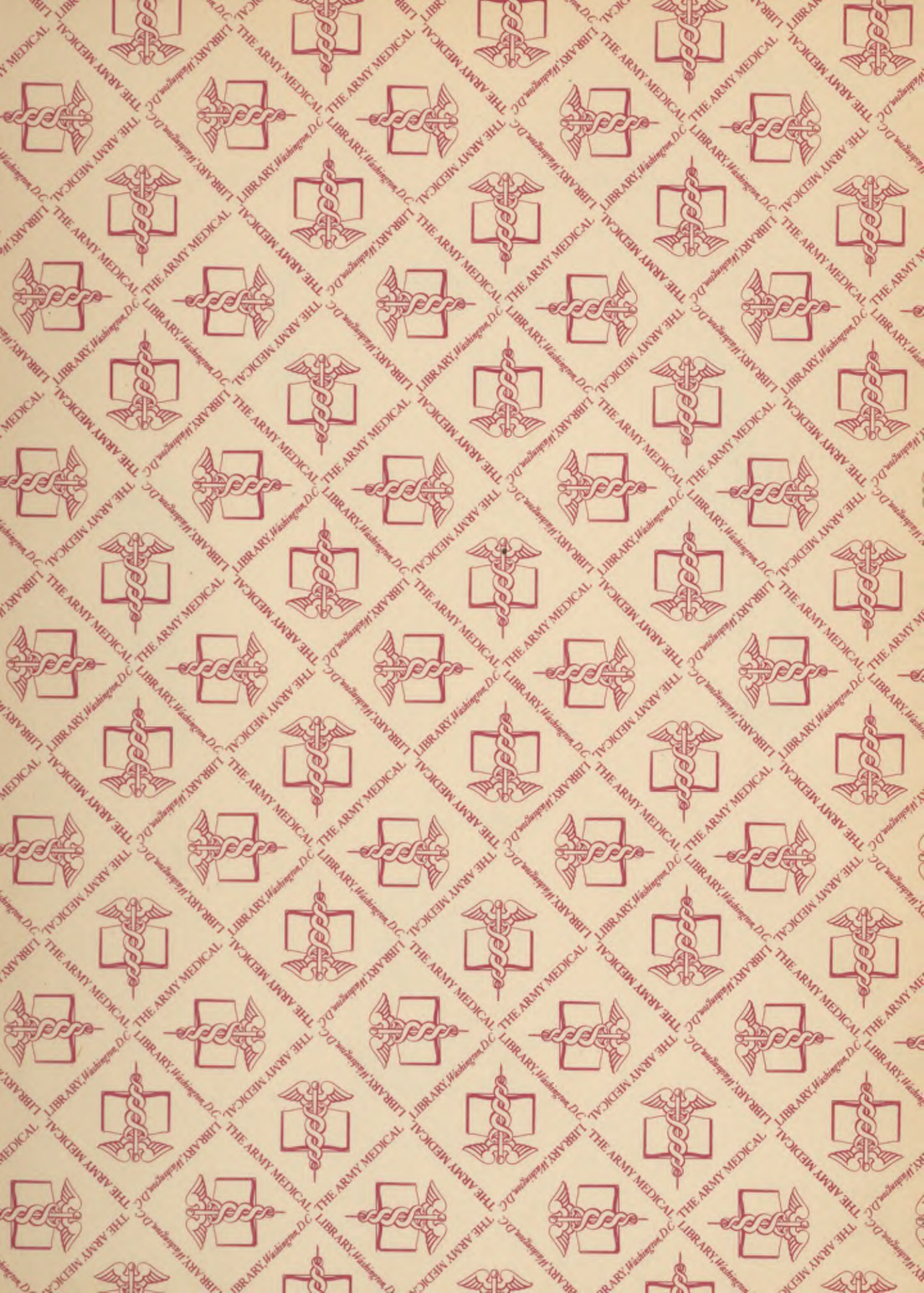
U. S. BUREAU OF MEDICINE AND SURGERY
NAVY DEPT.

ASIATIC SCHISTOSOMIASIS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ASIATIC SCHISTOSOMIASIS

NavMed 642

U.S. Bureau of Medicine and Surgery
Navy Department
Washington, D. C.

1945

FOREWORD

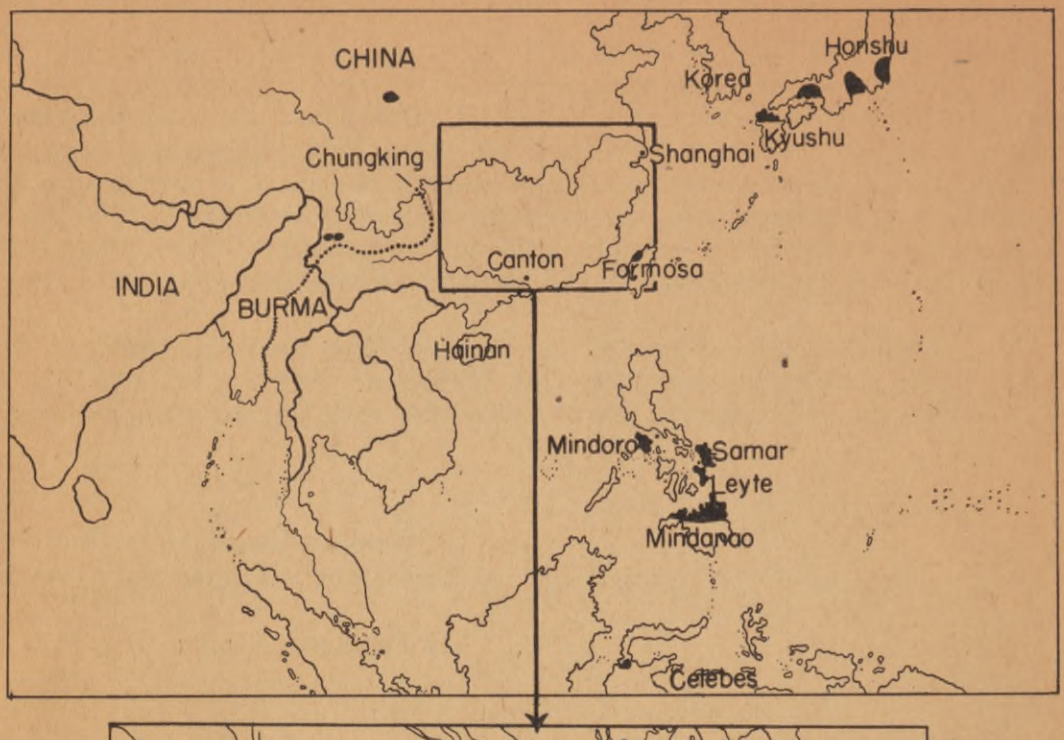
As the sphere of activity of the U. S. Navy extends itself into the Far East, additional problems arise in the maintenance of the health and efficiency of naval personnel. Among these problems is Asiatic Schistosomiasis or schistosomiasis japonicum. The life cycle of the etiologic helminth, Schistosoma japonicum, was discovered more than thirty years ago and since that time constant research and investigation have developed an extensive fund of useful knowledge. The purpose of this manual is to present a concise, authentic summary of useful information on schistosomiasis for the personnel of the Medical Department of the U. S. Navy.

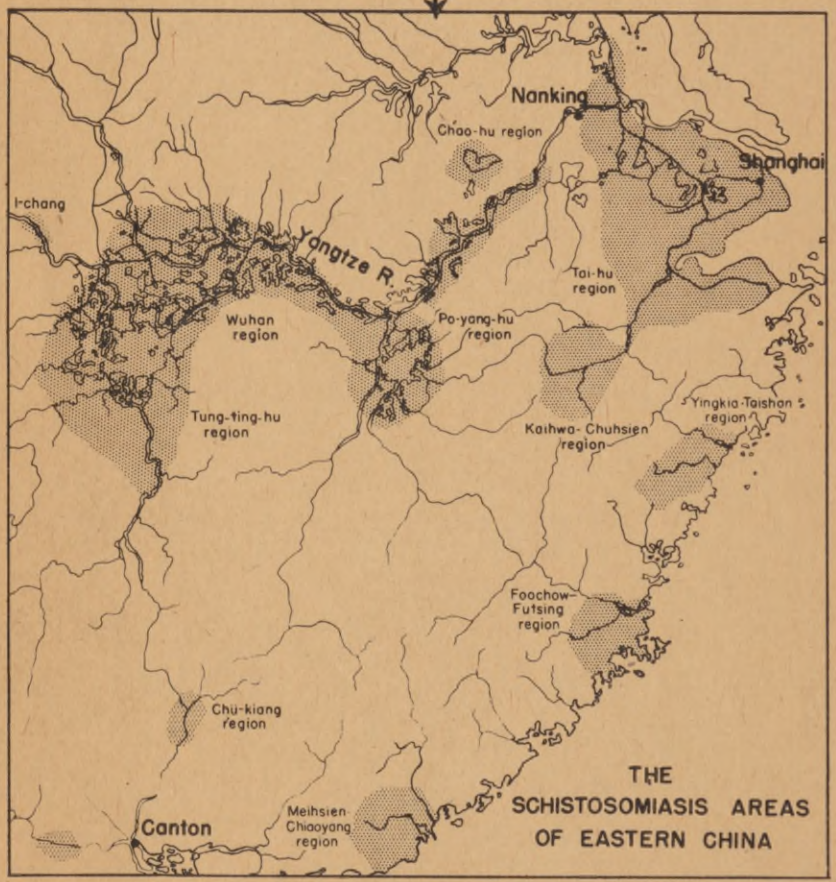
This manual has been prepared and assembled by the Department of Tropical Medicine, Naval Medical School, Bethesda, Maryland. The Professional Division, Bureau of Medicine and Surgery, has reviewed the material on diagnosis and therapeutics.

Preventive Medicine Division
Bureau of Medicine and Surgery

12 February 1945

DISTRIBUTION OF ASIATIC SCHISTOSOMIASIS





ASIATIC SCHISTOSOMIASIS

Asiatic schistosomiasis is a helminth infection caused by the invasion of the body by the Asiatic blood fluke, Schistosoma japonicum. The infection is characterized by alterations in metabolism, particularly in the liver where hypertrophy and cirrhosis take place; a dysentery due to eggs bursting through the intestinal wall; rectal papillomata; toxemia, edema, ascites, and emaciation. This disease is also known as Katayama disease, Yangtze Valley fever, Hankow fever, urticarial fever, and snail fever.

GEOGRAPHICAL DISTRIBUTION

Asiatic schistosomiasis is confined to the Far East:

Japan. There are four endemic centers in coastal river valleys; three are on Honshu and one on Kyushu. The Honshu foci are as follows: (1) northest of Tokyo in the Tone River district; (2) near Mount Fuji; and (3) in Okayama. The focus on Kyushu is in the extreme northern part of the island.

China. The most extensive and severe endemic areas are in China. In many parts of this country, schistosomiasis is a major public health problem. It occurs in the Yangtze River basin in the territory immediately watered by the main current, as well as in the area surrounding the adjacent lakes and important central tributaries. The endemic area extends further to the south of the river than to the north. In the coastal region there are endemic areas in the Yangtze delta south to Muiluk, as well as in the North and West river districts in Kwangtung. Two foci are recognized in Yunnan Province, one in Kwangsi and one about three hundred miles northwest of Chungking.

Formosa. The disease has been reported from Hokuto in the west central part and from the region around Shinchiku in the northwest part of the island.

Philippines. The islands of Leyte, Samar, Mindanao, and Mindoro are involved; possibly others in this group may contain endemic foci.

Celebes. The Lake Lindöe area is the reported focus. Fork-tailed cercariae have been recovered from snails in the Lake Poso area, which suggests the possibility that this region may be endemic. However, further investigation is necessary to determine the authenticity of this observation.

It is a well-known fact that the distribution of the snail intermediate hosts exceeds the present known distribution of the disease. It is possible that undiscovered endemic areas exist and that new endemic areas are being established because of the migration of infected people, particularly under wartime conditions. Moreover, it is possible that enemy personnel may be infected and therefore can be responsible for the establishment of new foci of infection.

ETIOLOGIC AGENT

The adult worms are dioecious. The male is elongate, measuring up to 12 mm. in length and 1.2 mm. in breadth. The deeply folded groove along the mid-ventral line, extending from behind the ventral sucker to the posterior end, is known as the gynecophoral canal in which the female lies. The suckers are small but very muscular. The male is distinguished by having seven testes behind the ventral sucker. The female is slender and filiform, usually longer than the male but in life rarely exceeding 0.1 mm. in diameter. The eggs are deposited in the smaller veins of the submucosa where they break through into the lumen of the gut. The mature eggs are ovate and have an abbreviated or rudimentary spine. They measure from 60 to 100 micra by 45 to 75 micra.

LIFE CYCLE

The following material supplements the information given in the chart:

1. The adults live in the venous plexus of the small intestine. Here the eggs are laid and are forced by the body movements of the host through the tissues into the lumen of the small intestine or colon.
2. The eggs are usually mature when passed in the feces and, under favorable conditions, hatch almost immediately in the water.
3. The miracidia must penetrate the tissues of a suitable snail within a period of about thirty-two hours; after this period they are no longer infective.
4. Within the snail, there are two sporocyst generations which finally give rise to the cercariae which in turn escape into the water. The latter are produced continuously in small numbers by the daughter sporocysts.
5. The cercariae do not have a second intermediate host. They attack men, dogs, cats, hogs, cattle, or horses. The cercariae remain infective from 1 to 3 days.

EPIDEMIOLOGY

Man becomes infected while bathing, wading, or washing clothes or by drinking water containing the infective cercariae. Only a short exposure (less than a minute) is necessary to permit infection. The cercariae penetrate the skin, lose their tails, enter the peripheral veins, and are carried through the pulmonary and systemic circulation, finally reaching the portal vein where they mature. After pairing, the worms migrate against the flow of blood to the mesenteric venules. In certain instances, only male worms may be present; in such cases they remain in the portal vein until such time as subsequent infection with female worms occurs.

Snails of three genera, Oncomelania, Katayama, and Schistosomophora, serve as the intermediate hosts of this blood fluke. The name Blanfordia has sometimes been applied erroneously to Katayama. The genus Blanfordia, although morphologically similar to Katayama, apparently has no role in the life cycle of Schistosoma japonicum. The period of time that the parasite spends in the snail host may be from one to three months. The cercariae die if a suitable host is not found within 72 hours after leaving the snail.

LIFE CYCLE OF SCHISTOSOMA JAPONICUM

ADULTS IN VENULES AROUND SMALL INTESTINE

Eggs are laid in venules and are forced through tissues to lumen of intestine and pass out with feces.

EGG which is mature when passed reaches water and hatches almost immediately and releases a miracidium.

MIRACIDIUM seeks out an appropriate snail and becomes a sporocyst.

MOLLUSCAN HOST

SNAILS of the genera Oncomelania. Katayama or Schistosomophora

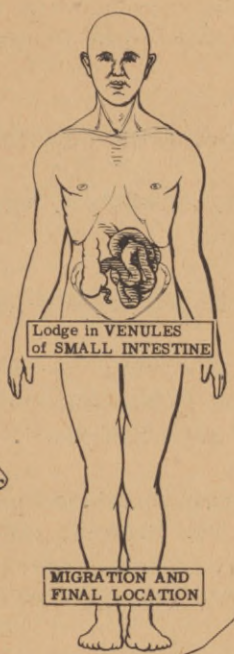
SPOROCYST which produces daughter sporocysts.

DAUGHTER SPOROCYST gives rise to cercariae which escape from snail.

CERCARIA free in water.

Young flukes mature in blood vessels.

Penetrates skin



MAMMALIAN HOSTS

NAVAL MEDICAL SCHOOL '44

CLINICAL AND PATHOLOGICAL FEATURES

The factors responsible for the pathological and clinical picture are as follows:

1. Mechanical Contact.

Cercariae invading the skin produce a severe itch which is partly mechanical and partly toxic. Eventually the portal system becomes the site of phlebitis and thrombosis provoked mechanically by contact with the worms and by the slowing of the current.

2. Toxins.

Katabolic products, liberated by the worms into the general circulation, act on the liver, kidneys, and spleen and the circulatory system. Under certain circumstances, an effect on the nervous system may be manifest. The toxins are classified as follows:

a. Hemoclastic, producing anemia and decrease in hemoglobin.

b. Leucocytotic, increasing the number of white corpuscles, especially lymphocytes and eosinophils.

c. Pyrogenic, affecting the heat regulating mechanism.

d. Neurotoxic, affecting certain groups of cells or nerve centers in the brain. To this is attributed certain symptoms such as lassitude, irritability, sleeplessness, apathy, and prostration.

e. Cytotoxic. Cellular poisoning is noticed particularly in the kidneys, liver, and spleen. The change in the kidneys, as shown by the presence of albumin and casts, and in the liver and spleen, as shown by enlargement, is probably caused by the toxins themselves or by poisonous products of tissue disintegration.

f. Anaphrodisiac. Cases of infantilism as well as premature senility are observed in a certain percentage of infected individuals. Menstrual cycles are disturbed.

A derangement of the calcium and phosphorous metabolism which is attributed to schistosome toxins also has been observed.

3. Ova.

The presence of the ova in the tissues provokes intense inflammatory cellular accumulations which may be followed by fibrous tissue hyperplasia. In addition, the deposition of eggs in tissues interferes with normal blood flow, which, coupled with mechanical distention, leads to necrosis.

4. Hematin Pigment.

Hematin pigment discharged from the worms may be found in liver, spleen, or kidneys.

Clinical and Pathological Features

The course of the infection may be divided into three stages: (1) the period of incubation which is here defined as the period between infection and the first appearance of eggs in the feces; (2) a period of egg deposition and extrusion; and (3) a period of tissue proliferation and repair.

1. Period of incubation. A tingling sensation in areas where cercarial penetration has taken place is felt soon after leaving the water. About four weeks after infection, pains develop in the back, epigastric region, and legs or along nerve tracts. Afternoon fever often occurs and is associated with loss of appetite, dry hacking cough, and general malaise. Nausea and vomiting may develop, and diarrhea may supervene. Lungs show transient areas of consolidation.

There is usually an intense urticaria with localized edema involving subcutaneous tissue. The wheals vary from a few millimeters to several centimeters in diameter and are raised, firm, round or irregular in contour, and surrounded by broad red areloa. A generalized pruritus develops which may last from one day to two weeks. There is usually a leucocytosis and a more or less intense eosinophilia. Blood in feces occurs only in the presence of heavy infection. The pathological lesions produced by this parasite during this stage of maturation and migration have been studied in experimental animals. They consist of:

a. Definite skin eruptions associated with cercarial entrance.
b. Lung lesions produced by the parasites; in heavy infestations these have a gross appearance of diffuse hemorrhagic pneumonia.
c. Lesions in stomach, kidney, and other organs due to the escape of immature schistosomes from vessels.

2. Period of egg deposition and extrusion. This period is characterized by dysentery with eggs in the stool and daily fever, epigastric pain, anorexia, and loss of weight. The liver is somewhat enlarged and the spleen may be palpable. After a period of three to ten weeks, the patient, if untreated, slowly regains his strength; his temperature returns to normal, and he may return to work. Special exertion may cause a recurrence of symptoms. The blood picture is that of a secondary anemia and, at times, leucopenia.

The primary pathologic process responsible for the clinical picture of this stage is the development of multiple lesions around the eggs which have been extruded into the intestinal wall and liver tissue. The adult worms are in the capillaries of the submucosa of the intestine; the eggs are deposited still further distally in the capillaries. Slight pressure causes a rupture of the intestinal epithelium and the nearest eggs are extruded into the lumen. Inflammation first appears in the submucosa and mucosa, but, later on, muscular layer and serous surface are also involved. Microscopically these lesions usually consist of single eggs which are surrounded by concentric layers of white cells, conspicuous among which are the eosinophils. Thus, the typical schistosomiasis abscess is formed. This minute abscess frequently breaks through into the gut, discharging its contents through small openings between intestinal glands.

Meanwhile, many of the eggs are carried to the liver where they produce similar lesions. Numerous small abscesses may coalesce forming larger lesions which become encapsulated with resultant replacement of liver tissue. Cells of the liver characteristically engulf the hematin which is discharged by the adult worms. Congestion of the spleen usually accompanies the liver damage. An increase in the size of the mesenteric lymph nodes may occur, but the factor responsible for this phenomenon has not been identified.

3. Period of tissue proliferation and repair. The essential pathological and clinical picture in the third period is as follows:

a. Great thickening of the intestinal wall occurs due to scar formation.

b. With this thickening, more and more eggs are swept back into the liver, serving as an additional factor in producing cirrhosis.

c. Enlargement of the spleen is caused by a marked increase in the fibrous reticulum as a consequence of circulatory congestion.

d. In the late stage, eggs may be carried to lungs, eye, or brain with resultant abscess formation in these organs.

e. When the liver becomes markedly cirrhotic, ascites and edema of the extremities may develop. The patient may finally die of exhaustion or some terminal infection.

The first stage in japonicum infection is of about six to eight weeks duration. The duration of the second and third stages varies with many factors, the most important one being the severity of the infection. Very heavy infections may terminate in death in less than six months while other lighter ones may persist twenty years or for the life of the individual and may act only as a contributory cause of death.

PROGNOSIS

Since there is no multiplication of this parasite after its entry into the body of its final host, the severity of the disease in any one case depends upon the number of cercariae which penetrate the skin. In cases which have been exposed to infection only once, the disease is rarely, if ever, fatal. Repeated infection is, therefore, the first factor in prognosis. The second factor is the period of the disease at which therapy is instituted. Early diagnosis and prompt and adequate therapy are of utmost importance in a favorable prognosis. Conversely, heavy infections, late diagnoses, and/or inadequate therapy are factors in an unfavorable prognosis.

DIAGNOSIS

Schistosomiasis should be suspected in the presence of urticaria, eosinophilia, dysentery, and liver or spleen enlargement occurring in endemic areas.

During the incubation period the presence of a cercarial rash which appears shortly after exposure followed after an interval by giant urticaria with other symptoms described above may be sufficient to establish a tentative diagnosis.

A specific diagnosis can be readily established after the first period only by recovery of the eggs in the feces or in the tissues removed at operation or autopsy. Frequent stool examinations should be made in all suspected cases. Routine stool examinations of all personnel serving in endemic areas should be carried out at three month intervals in order to detect inapparent or latent infections. (See section on Surveys for technique.) Eggs can be recovered from tissues by soaking these in three per cent potassium hydroxide.

A complement fixation test, utilizing an extract of infected snail livers as an antigen, has been used by various workers but is not, as yet, in general use.

Asiatic schistosomiasis must be differentiated in the first stage from typhoid, miliary tuberculosis, and other chronic febrile diseases as well as foreign protein intoxication. During the second stage it must be differentiated from amebiasis and bacillary dysentery. In the third state it may be confused with kala-azar, malaria, Banti's disease, or non-schistosomal cirrhosis.

TREATMENT

In endemic areas, medical officers must be on the alert for schistosomal infection, for with early treatment complete cure is possible while, if the infection is allowed to progress, treatment often is of no avail due to the irreversible fibrotic changes of the liver, intestines, and other organs.

a. Fuadin (neoantimosan) intramuscularly; 1.5 cc., 3.5 cc., and 5.0 cc. on successive days, then 5.0 cc. on alternate days to a total of 10 doses. Toxic symptoms: vomiting, joint pains (rare). If toxic symptoms appear, reduce dosage. If eggs containing living embryos are found after completion of treatment, repeat the course after a rest of two weeks. (See "b" below.)

b. If a satisfactory response is not attained with these courses of fuadin, use potassium antimony tartrate (USP), two per cent freshly prepared solution intravenously on alternate days. Initial dose 2.5 cc. (0.05 gm.); increase each subsequent dose by 1.25 cc. until 7.5 cc. are being given. Continue until a total of 12 to 15 doses have been given. Administer the drug two to three hours after a light meal and have the patient lie down for one hour. If toxic symptoms appear—nausea, vomiting, dizziness, and collapse—dosage must be reduced; coughing, which often occurs immediately after the infection, is not important.

Antimony preparations are contraindicated in the presence of nephritis, jaundice, or severe liver disease.

c. Emetine hydrochloride may be used if the above preparations are not available. The dose is 0.06 gram (1 grain) daily, by intramuscular injection, for ten days. Toxic effects: lowering of blood pressure, vomiting, acute myocardial symptoms.

d. Diet. Patients should be given a high caloric diet. If evidence of hepatic disease exists, the diet should be high in carbohydrates and low in fats. Milk, eggs, and cheese are permissible. If anemia develops, iron is indicated. The addition of vitamin A and vitamin B complex is advised.

e. Criterion of cure: cessation of passage of eggs containing live embryos. If cure is not obtained, repeat treatment after two weeks.

PREVENTION

Medical officers should acquaint all personnel with the manner in which schistosomiasis is contracted and spread. Every precaution should be taken to prevent swimming, bathing, wading, or washing clothes in infected water. In endemic areas, the use of untreated water for any purpose should be prohibited. The importance of education in the prevention of schistosomiasis cannot be overemphasized since prophylaxis resolves itself so distinctly into personal preventive measures.

Boiling of water is the most certain method of killing cercariae. Whenever possible, water should be stored for at least 72 hours, the maximum period for cercarial survival; then, after routine treatment, it may be used for all purposes.

Sanitary control of natives and animals around bases is desirable. Copper sulfate in a concentration of 1:200,000 will kill cercariae. The usefulness of DDT as a cercaricide has not as yet been determined. Control of the intermediate hosts is difficult: the use of copper sulfate is not practicable as the snails are amphibious and can leave the water during the relatively short period of time in which this chemical is effective. The use of lime along the edges of ponds, irrigation ditches, streams, etc., produces an alkaline environment unsatisfactory for the schistosomophorous snails and has been found effective in controlling the disease in certain areas.

SUGGESTED PROCEDURE FOR AN ASIATIC SCHISTOSOMIASIS SURVEY

The exact distribution of this infection is not known. Naval forces operating in oriental areas must assume that schistosomiasis is endemic until careful surveys have been made.

Examination of Mammalian Hosts

The examination of stool specimens from the native population for ova will give a fair index of the importance of the disease. It is important that people who have resided in the area for some time are selected for study. Samples from children are desirable since, when infected, they are more likely to have local infections. Stool specimens from animals, such as dogs, cats, cattle, water buffalo, should be examined for ova, and/or tissues should be examined for adult worms.

Regardless of the source of the fecal sample, the examination should be made as follows: A portion of the sample is suspended in a large quantity of water in a flask or cylinder, and the supernatant liquid is poured off as rapidly as settling occurs. Repeat the process by refilling the container with water and mix by shaking; continue until the supernatant liquid is nearly clear. This method serves to concentrate all the stages of helminths which may be present. Examine samples of the sediment for eggs by the smear method. Simple sedimentation may be improved by centrifuging an emulsified sample of feces in water.

This method is useful for all types of helminth ova. After the sediment has been examined, the material should be placed in a cylinder which is then filled with clean water. Twelve to twenty-four hours later, the upper portion of the water may be examined for the miracidia of schistosomes.

Examination of Intermediate Hosts

Several species distributed among three genera of small snails serve as intermediate hosts of the human schistosomes. Two points should be borne in mind constantly: (1) The snails are amphibious and usually spend more time out of the water than in it. (2) The snails are extremely small (5-9 mm. or 1/5 to 1/3 of an inch) and can be easily overlooked.

SCHISTOSOMOPHORA

Actual size Enlarged 17x

Schistosomophora

Species of this genus serve as intermediate hosts in certain of the Philippine Islands. All are less than 6 mm. in length. Snails of this genus are seldom encountered under water, but are most frequently found under dead leaves and other objects in moist surroundings above the edge of the water. They are often seen attached to the stems and leaves of grasses and weeds and to such objects as house and bridge posts, the position in every case being just a few millimeters above the surface of the water. They are not found in the vicinity of large rivers or their branches where the current is rapid. They appear to be dirty-water feeders, since they are found most frequently in ponds, irrigation canals, and irrigated rice paddies where human feces may be present. They can withstand prolonged desiccation. When the snail is at rest, the opening of the shell is sealed off by a tiny, horny operculum.

Oncomelania

Species of this genus are intermediate hosts in the Yangtze River Valley in China. The habits of one species, O. hupensis, are described by Faust and Meleney as follows:

"In warm weather it inhabits the moist earth, just above the water's edge, always within 50 cm. of the water and usually within 10 cm., or it is found attached to the earth, to stones, or to the stems of grass or plants growing out of the water. It prefers sloping banks but avoids exposure to the sun. It must therefore be searched for in secluded spots, beneath loose grass, under projecting clods of earth, or beneath stones. The bodies of water on whose shores it is found are relatively clear, cool, and still. It has not been found in large canals where there is much traffic and where there is, therefore, much movement of the water, but may be found not over four or five meters from such a canal, in a small terminal branch. It may be found singly or in groups ....

ONCOMELANIA

Actual size Enlarged 15x

Oncomelania

.....It is occasionally found on stones or roots of grass a few centimeters below the surface of the water, but dredgings of deep-water grass have not been found to contain it, nor has it been found in the bottom of a canal on whose shore it was abundant.

"In the laboratory, if placed in a deep glass dish in shallow water, it usually climbs out from the water in a few minutes, on the side of the dish away from the window, and, after creeping far enough to free itself from water, will fasten its shell to the glass by mucus at the aperature, retreat into its shell and remain there for hours or days. It may drop or creep back into the water, or may possibly remain desiccated until death. Reimmersion in water after such drying usually brings the snail rapidly out of its shell and into full activity."

KATAYAMA

Actual size Enlarged 15x

Katayama

Species of this genus are found in Japan, Formosa, and the southern half of China. Those species which serve as intermediate hosts occur in damp moss and grass on the sides of irrigation canals.

Examination of Intermediate Hosts

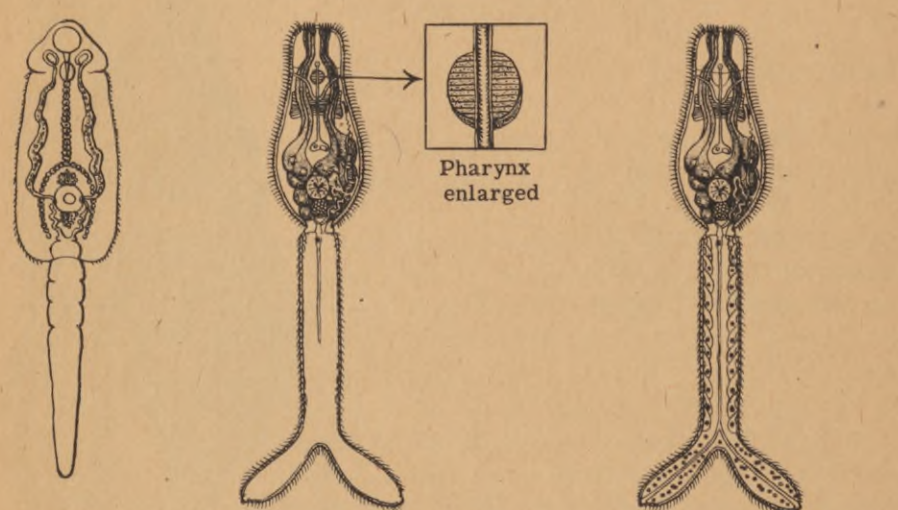
Great care must be exercised in collecting snails suspected of harboring immature stages of schistosomes. Since infection may result from contact with a snail from which cercariae are escaping or from contact with water containing cercariae, it is advisable to wear rubber gloves and boots. A small net with a coarse mesh may be used to separate the snails from the mud. Snails which are resting in moss may be obtained by shaking small quantities over a pan, screen, or pieces of burlap. Those which are resting on plants may be removed with forceps.

Snails which are brought in the laboratory should be placed in half-pint bottles, in lots of about a dozen. A gauze top should be placed over the jar to prevent the snails from escaping. Each jar should be examined daily for emerged cercariae. It may be desirable to isolate the snails, once cercariae are demonstrated, in order to ascertain the source of cercaria production.

Cercariae can be found by macerating the snails digestive gland which is located in the spire. The shells of these snails are quite delicate and if care is exercised they may be cracked without injury to the tissues within. The pieces of shell should be removed and the digestive gland exposed, macerated, and examined. Cercariae obtained in this manner may be immature and unlike those escaping naturally; therefore, this procedure should be used only if there is not sufficient time to await the normal emergence of cercariae.

Insofar as possible, cercariae should be examined in the living state with the help of such stains as neutral red or nile blue sulphate (1:1000). Cercariae of the family Schistosomatidae are characterized by (1) the presence of a forked tail and (2) the absence of a pharynx.

TYPES OF CERCARIAE



Unforked tail | Forked tail; pharynx present | Forked tail; pharynx absent

SCHISTOSOME TYPE

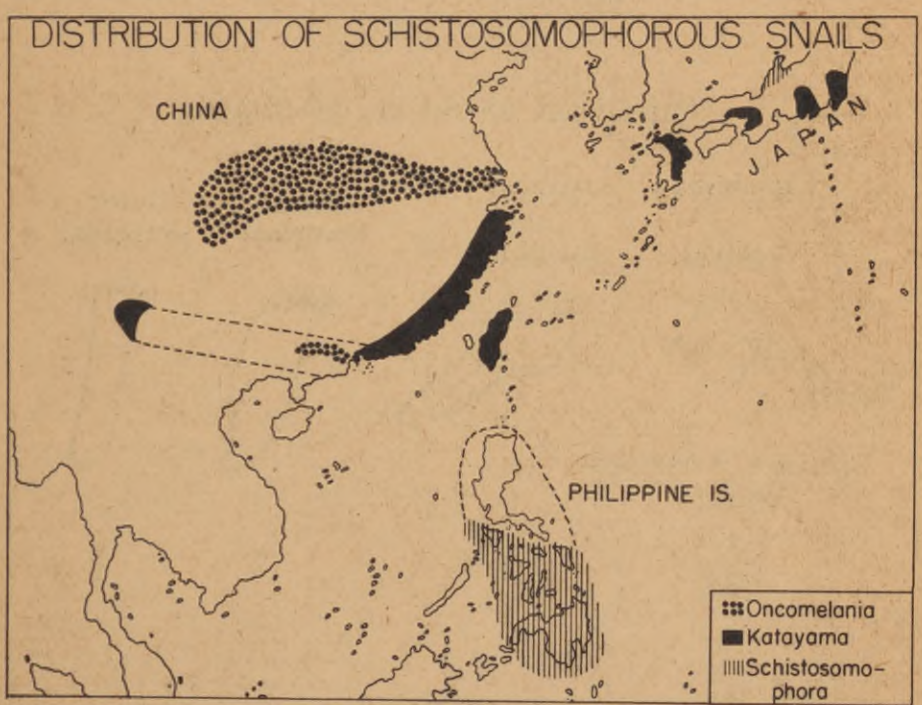
Technical Appendix - The Intermediate Hosts

Thus far, only three genera of shells, all belonging to the sub-family Hydrobiinae of the family Bulimidae (not Bulinidae) have been implicated as intermediate hosts of Schistosoma japonicum. In the Philippines the genus Schistosomophora is exceedingly close in all its characters to Katayama of China. The Philippine Schistosomophora shells are all quite small (max. 5 mm.). They are recorded from Mindanao, Leyte, Samar, Mindoro, and Lubang Islands but not, as yet, from Luzon. Easily confused in the Philippines with Schistosomophora are the tiny Tricula shells which, however, are distinct in having the lower lip flaring and quite expanded.

Oncomelania: Eight species in the Yangtze River system, one species in the Canton, China area. See illustration of shell. Shell, when cleaned of detritis, waxy yellow color; averaging 8 or 9 mm. in height; ribbed; with a strong varix on the body whorl just behind the edge of the lip.

Katayama: Four species along the east coast of China, one in Yunnan Province, one in Formosa and two in Japan. See illustration of shell. Shell, when cleaned, waxy light brown; averaging 8 to 9 mm. in height; without ribs, and with a strong varix on the body whorl just behind the edge of the lip. Last or body whorl is less than half the total height of the shell.

Schistosomophora: One or possibly two species in the Philippines (common) and one small (not yet implicated) species in Japan; shell, when cleaned, waxy light brown; averaging 5 mm. in height; without ribs, and with a relatively strong varix on the body whorl just behind the edge of the lip. Last or body whorl is much greater than half the total height of shell.



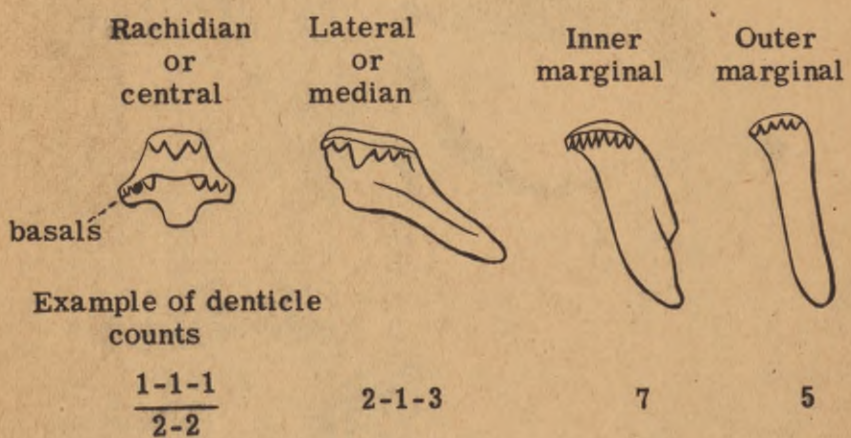
Technical Appendix - The Intermediate Hosts

Collection of Snails

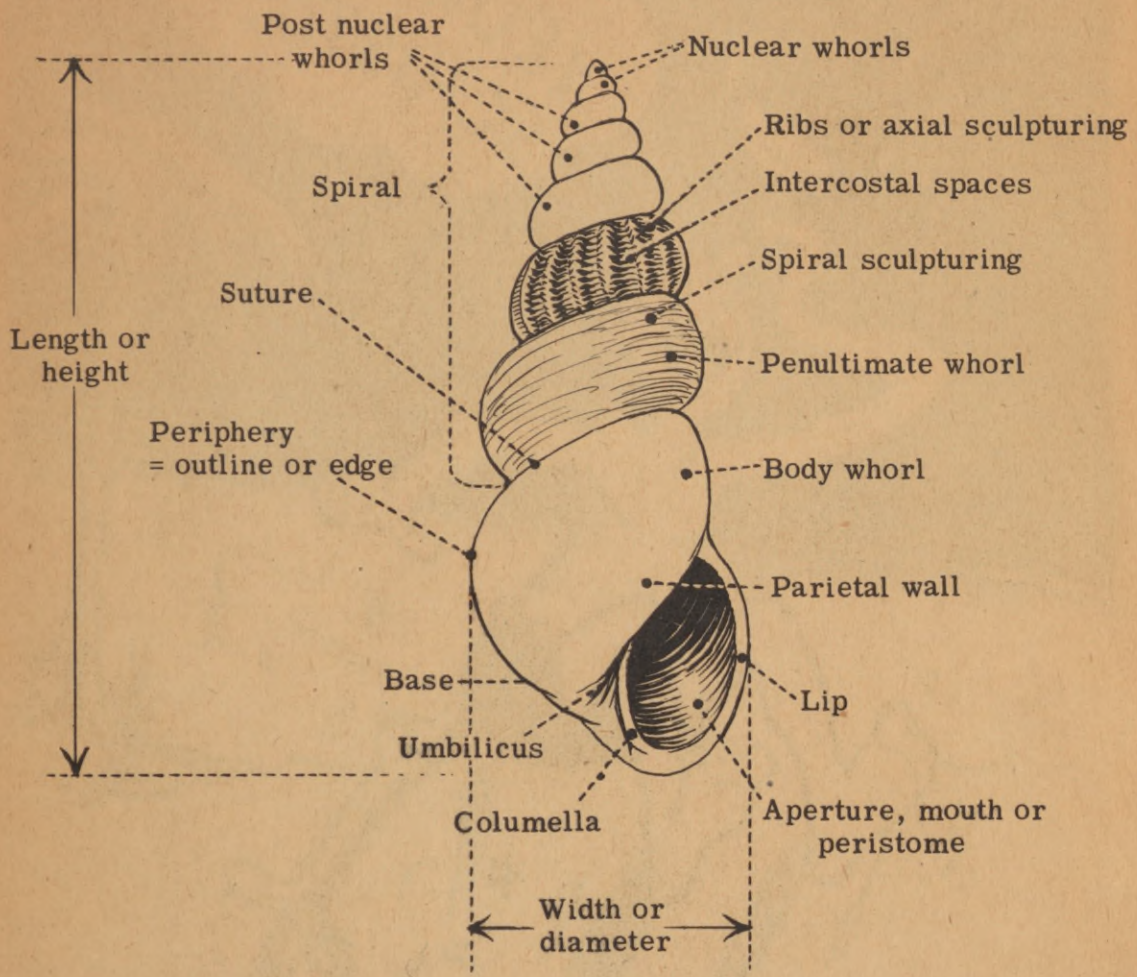
The distribution of schistosomophorus snails is poorly known. Therefore, a distinct contribution can be made to the knowledge of schistosomiasis by procuring collections of species suspected as intermediate hosts and transmitting them to the Naval Medical School, National Naval Medical Center, Bethesda 14, Md. Such material is referred to the U. S. National Museum for identification and becomes a part of the collection of that institution or a part of the teaching collection at the Naval Medical School. Identifications of material transmitted from the field are returned to the collector at the earliest possible time. Collecting data should always be included. Of particular importance are geographical and ecological information. Specimens should be preserved in 70 per cent alcohol, never in formalin, and shipped in vials. Wrap larger, empty dry shells in paper.

Radula: Each animal possesses a lingual ribbon or file-like set of teeth called the radula which is set in the buccal cavity of the head. It may be used as an aid in identification of genera and species. The lingual ribbon is built of thousands of tiny teeth of a glass-like substance arranged in closely packed rows. Each row has seven teeth, one central tooth or rachidian bordered on both sides by three different teeth: the lateral or median, the inner marginal, and the outer marginal. Preparation: heat head gently in strong KOH; needle away flesh; wash in water; stain in mercurochrome; transfer to 90%, then 98% alcohol, then xylol. Mount in Canada balsam on slide. Break teeth apart with needles before applying slide cover. Label with locality data. Enough variation in denticle counts has shown that radulae are helpful, but not final in identification.

TEETH OR RADULAE OF SNAILS



MOLLUSCAN NOMENCLATURE

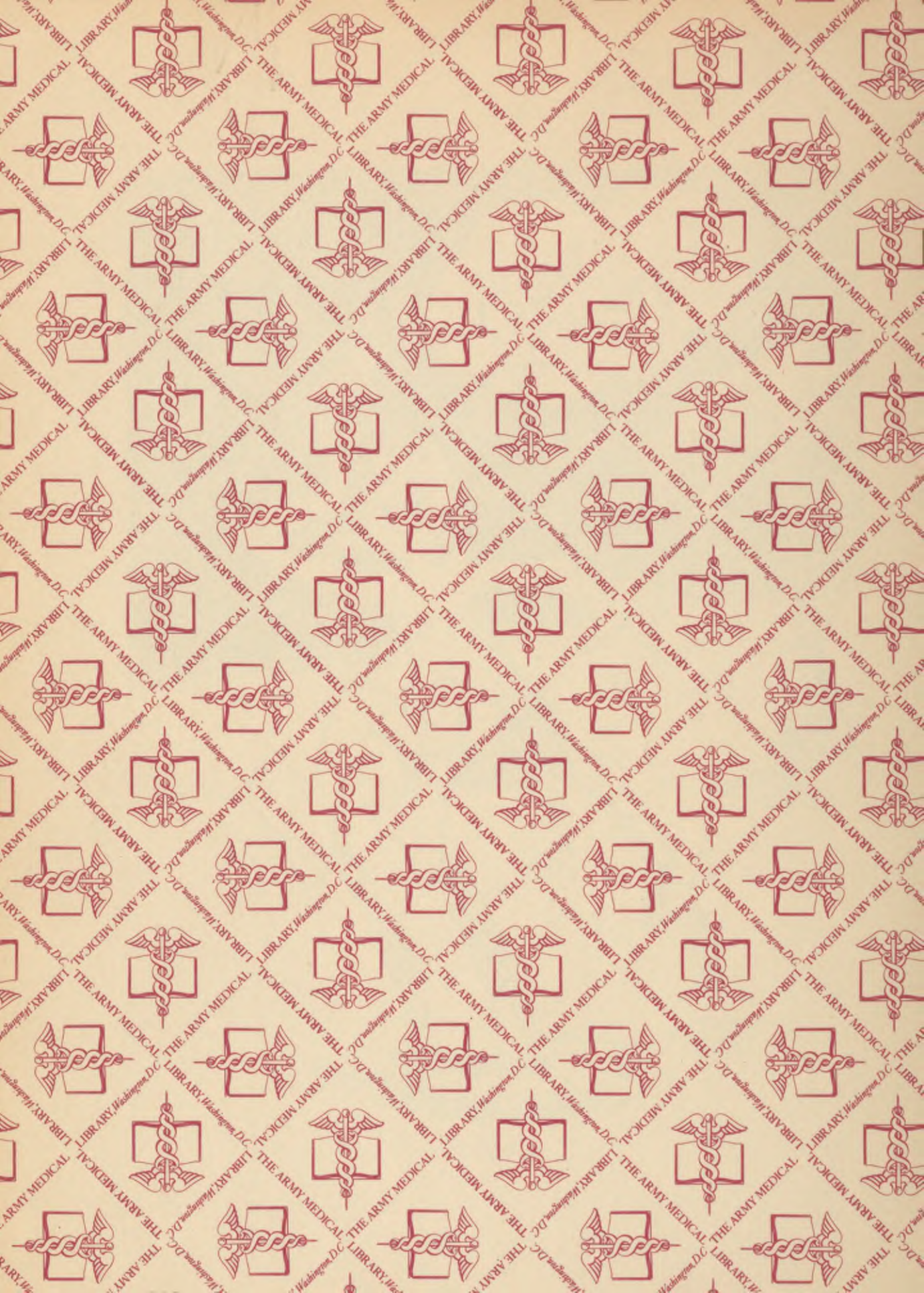


Periostracum: thin, protective coating or "skin" over the outside of shell.

Operculum: corneous thin trapdoor attached to foot of animal. Fits snugly into aperture.

Varix: thickening of shell just behind the lip on the outside of body whorl.


YEOW
SCHISTO!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