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MZOE-001: Parasitology
Guess Paper-1

Q1. Describe the types of hosts.

Ans. The organism harbouring the parasite is called as host. The hosts are of different types based on requirement of parasite and host-parasite relationship. A few criteria of classifying hosts are discussed below.

Stage of Parasite's Development: The hosts can be categorised into four kinds according to which stage of parasite develops and multiplies within it. These are as follows.

a) Definitive Hosts: They are also called as primary or final hosts. They harbour a parasite usually in the adult stage which undergoes sexual reproduction in the host. E.g. Man is the definitive host for Taenia solium, Fasciola hepatica, etc.

b) Intermediate Hosts: These hosts usually harbour larval stages of the parasite which develop or multiply through asexual reproduction. For example, pig is an intermediate host for Taenia solium and snail is the intermediate host in the life cycle of Fasciola hepatica. These hosts are also called as secondary hosts.

c) Supplementary Hosts: Some parasites complete larval development in two different intermediate hosts. They are referred to as first and second intermediate hosts. The second intermediate host is also called as additional or supplementary host. For example, carp fish (freshwater fish) is a supplementary host for Opisthorchis felineus (Cat liver fluke) while snail is the first intermediate host.

d) Paratenic Hosts: They are also called as transport hosts. In these hosts, parasites do not undergo development into next stage. Instead, paratenic hosts play a major role in spreading parasite species, especially nematodes. Thus, these hosts serve as a temporary refuge and a vehicle of the parasites to help them reach the definitive host.

e) Reservoir Hosts: The reservoir hosts harbour the invasion stages of parasites for the transmission to another host. It is usually not affected by the infection as the parasite does not undergo any further development in it. Wild rodents are the examples of reservoir hosts which harbour fleas and Leishmania, while predatory fish serve as reservoir hosts for the larvae of fish tapeworm.

Conditions for Parasite's Development:

a) Obligatory or Natural Hosts: These hosts ensure the best conditions for the development of parasites. The biocoenotic ties and optimal biochemical conditions provided by the host enhance the fertility of parasite, provide best survival rate and help in their quick development. For example, humans are natural hosts for Ascaris lumbricoides.

b) Facultative Hosts: These hosts, though show biocoenotic ties but do not provide the optimal biochemical conditions. As a result, in these hosts, duration of parasite's life is shortened or parasite does not have a full development cycle. For example, cat is a facultative host for fish tapeworm.

c) Potential Hosts: These hosts do not have biocoenotic ties with the parasite but they ensure optimal biochemical conditions for parasite development. For example, herbivorous animals can act as potential hosts for Trichinella spiralis.

Transmission Agents of Parasites: Vectors act a host of parasites and carry them either within the body or outside their body in order to transmit parasites to another host. Accordingly, vectors are of two kinds.

a) Biological or true vectors: In these vectors, the parasites undergo development or multiplication. It is specific for a particular parasite and generally harbours the parasite internally, where some part of their life cycle is completed. For example, Glossina palpalis (tsetse fly) is a biological vector of Trypanosoma gambiense, in which the parasite develops as well as multiplies. The filarial worm, Wuchereria bancrofti is transmitted to humans by Culex sp. where it develops but does not multiply. Other examples of these vectors are Phlebotomus argentipes for Leishmania donovani and Anopheles for Plasmodium sp.

b) Mechanical Vectors or Carriers: They assist in the transfer of parasitic forms between different hosts but they are not essential in the life cycle of the parasite, as parasite does not develop further or multiply in them.

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It just picks the parasite from one host and drops on the other. These are non-specific to the parasites and they generally carry the parasite outside their body which clings to their hair, spines or other parts of the body surface. The examples include house fly, cockroaches, ants etc.

Q2. Discuss the co-evolution of parasites and their hosts.

Ans. Evolution can be defined as a change in gene frequency between generations, but in order for this to occur, three criteria need to be met. First, there must be genetic variation within the population. If the population is genetically homogeneous, then variation can only occur sporadically through random mutation. The second criterion is that the variation must be heritable. If the variation cannot pass on to offspring, then it will be lost regardless of the benefits it imparts. The third and final criterion is that the variation must influence the probability of leaving reproductively viable offspring. Parasites live in close association with their hosts and the two organisms will co-evolve. The nature of the host-parasite relationship may therefore, change with time. For example, provided the above three criteria are met, the host can be expected to evolve resistance/susceptibility factors depending upon the pressure exerted by parasite.

Evolutionary Relationships between Host and Parasite: It is often stated that the longer a parasite and its host have been living in association, the less pathology is caused. This is based on the reasoning that if the parasite kills its host, then it will effectively 'commit suicide' because it will have destroyed its food supply. Consequently, over time, it is to be expected that the parasite will become less harmful to its host – that is, it becomes less virulent. For example, let us consider two hypothetical strains of the same nematode species, A and B, that live in the gut of sheep. Strain A is highly virulent and causes the death of the sheep while strain B is relatively benign and seldom causes any mortality. At first glance, one might expect that strain B would leave more offspring because its host lives for longer. However, if virulence was linked to the nematode's reproductive output and the eggs were released at a time when they were likely to infect new hosts, then it would be strain A that would bequeath more of its genes to subsequent generations. Thus, the proportion of strain A in the nematode population would be expected to increase with time and there would be constant selection for ever increasing virulence.

Consequently, the evolutionary end-point of any relationship is very casedependent. Sometimes the parasite becomes more virulent, and sometimes its virulence attenuates to an intermediate level but one cannot assume that the natural end-point is a mutually beneficial form of mutualism. Indeed, the relationship between a parasite and its host is often likened to a 'co- evolutionary arms race' in which the parasites attempt to acquire more resources from the host in order to produce their offspring while the host evolves mechanisms for reducing its losses and eliminating the parasite.

Parasites and other pathogens are generally smaller than their hosts and reproduce faster. Consequently, they might be expected to win any arms race because of their ability to select for adaptations that overcome any new measure the host is able to generate and limits the parasite's acquisition of host metabolites. However, comparatively long-lived hosts usually have sophisticated immune systems that are able to identify and kill or neutralise new parasite variants. The host is, therefore, not a constant environment for the parasite.

Parasite virulence is also affected by the mode of transmission. Horizontally transmitted parasites, especially those with a wide host range, can 'afford' to be highly virulent because there are lots of potential hosts and if one or more of them dies, it has no direct consequences. However, when the parasite is vertically transmitted (e.g. via the eggs of its host or across the placenta), there is a direct link between the effect of the parasite on its host and its own reproductive success. It is therefore to be expected that, as a general rule (there will always be exceptions), vertically transmitted parasites should be less pathogenic than those that are transmitted horizontally.

Q3. What are the different types of life cycles seen in parasites?

Ans. Many organisms have adopted a parasitic lifestyle to some extent for their efficient survival. If one takes the view that the main purpose of any organism's existence is to ensure that as many of its genes as possible

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are transferred into the next generation, then all organisms should maximise their reproductive output. However, producing offspring is energetically costly and these costs have to be traded off against other activities such as finding food and then digesting and absorbing it, finding a mate, protecting oneself against predators and the environment. By living upon or within a host, a parasite can reduce many of these costs and thereby devote more of their time and energy to reproduction. Most parasites stay in association with their host for the duration of a life cycle stage. Therefore, having located and infected their host, the need for sensory apparatus and locomotion is reduced because the parasite has access to a guaranteed food source. This guarantee also means that the parasite does not have to extract as much energy as possible from each 'unit of resource'. Instead, it can afford to be wasteful and many parasites have reduced metabolic pathways. Furthermore, there is no need to lay down metabolic reserves beyond those required for the next life cycle stage. Parasites rarely need well-developed food gathering apparatus. Some parasites, such as the tapeworms, have dispensed with a mouth and gut altogether, relying on nutrients being absorbed across the body wall.

Main Advantages of a Parasitic Lifestyle: The parasites live within or upon their host because of which they have a reduced need to maintain body surfaces and behaviours that protect them from desiccation, heat, cold, as this is done by the host. Similarly, the parasite is, to a large extent, protected from predators and pathogens, which would have to overcome the host's immune system before locating the parasite. Even ectoparasites are protected to some extent because hosts are not always able to distinguish between a predator that is attempting to take a bite out of them from the one that is intent on removing a flea or louse.

A parasite will be transported wherever the host goes and therefore the limits of its dispersal depend upon the dispersal powers of its host, coupled with whatever other special needs the parasite has to complete its life cycle (e.g. the presence of a suitable vector or environmental conditions). Consequently, a parasite does not have to devote energy to dispersal.

Main Limitations of a Parasitic Life Style: Any would-be parasite must first overcome the putative host's immune defence and adapt to its internal physiological environment. This is not easy and as a consequence, most parasites are highly host-specific. However, host-specificity places the parasite in a difficult situation because its existence then becomes dependent upon that of its host. Should the host become extinct, then its parasites will follow suit unless they are able to infect other organisms. Furthermore, for the individual parasite, finding hosts is seldom easy. Although many parasites produce huge numbers of offspring, the chances of any one of them managing to locate a suitable host and reproduce successfully are extremely small. The advantages and disadvantages of the parasite lifestyle are summarised in Table.

Table: Summary of advantages and disadvantages associated with the parasite lifestyle.

Advantages	Disadvantages
Once host is located, no need for further searching	Extreme host specificity can increase vulnerability to extinction
Food permanently available; Limited requirement for complicated food capturing mechanisms; Reduced need for food processing	Must locate an optimal site on/in host to ensure food availability/survival
Protection from environmental extremes	Must adapt to host's internal physiological environment (internal parasites only)
Protection from predators and diseases	Must overcome host's immune defence
Reduced need for dispersal because host (+ vector) carries the parasite	Spread limited by host's geographic range
Can devote larger proportion of energy intake to reproductive output in comparison to a free-living organism	Transmission can be extremely risky and most offspring die before establishing in a new host

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Q4. Summarize key infections spread through soil, water and food in humans.

Ans. Soi: The organisms have to remain in touch with the soil in some part of their life cycle, whether it is an arboreal, aquatic or aerial mode of life. Human beings are not presenting an exception to this and they are bound to remain connected with the soil. The soil comprises a large number of pathogens, including nematodes and cestodes. These pathogens are transmitted to the human beings through the soil either by direct mechanism or through contaminated food items. These diseases frequently occur in humans living an unhygienic lifestyle. For example, Ascaris lumbricoides is transmitted to the human beings via ingestion of infected soil.

Water: Water is the ultimate need for all living beings. It acts as a major source of direct transmission of diseases by transmitting the parasite directly to the definitive host or as a source of indirect transmission of diseases wherein the parasite survives through its intermediate stages. Water-borne diseases pose highly significant challenges to the human life especially in the developing countries including India. The diseases are more frequent and severe during monsoon, floods and other water-related disasters. Amoebic dysentery is one such prominent disease in addition to many others that is transmitted through the contaminated water.

Food: Food is one of the main sources for many parasitic and zoonotic infections especially when domestic animals such as buffalo, cows, goat, camel, sheep, horse, yak and pigs are infected with parasites (such as Cryptosporidium or Trichinella). Human individuals can easily acquire cryptosporidiosis (caused by Cryptosporidium), if they accidentally swallow food or water that is contaminated with stool of infected animals. This can also happen when people consume the unwashed fruit or drink untreated water from the orchards or water sources located near domestic cattle/cow pastures. Similarly, people can acquire trichinellosis by ingesting undercooked or raw meat of bear, boar, or domestic pigs that are infected with the Trichinella parasite.

Q5. What are the various modes of infection of parasites in humans?

Ans. An infectious agent may be transmitted from its natural reservoir to a susceptible host in different ways. The modes of infection can be direct or indirect (Fig.).

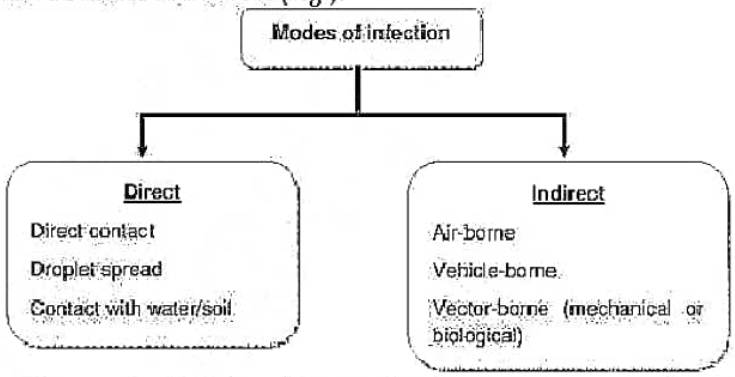

Fig.: Summary of modes of infection with general parasitic infection

Direct Transmission: An infectious agent can be transferred from a reservoir/infected host to another susceptible host by direct contact. This is referred to as direct transmission.

i) Direct contact: It may occur through skin-to-skin contact, kissing [infectious mononucleosis ("kissing disease")], or sexual intercourse. For example:

- A few diseases, such as chickenpox, conjunctivitis and ringworm. Spread via skin contact of an infected person with the skin of the other person.
- A few diseases, such as hepatitis and HIV spread through semen and vaginal fluids, saliva, when the body fluids/blood of an infected person come in contact with the mucous membrane/bloodstream of an uninfected person.

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ii) Droplet spread: The infected host can transmit the pathogens through direct projection of large or short-range aerosols produced by sneezing, coughing, or even talking. The expelled droplets are directly deposited on skin, conjunctiva or oro-pharyngeal mucosa leading to infections. Tuberculosis, pertussis and meningococcal infections, etc. are transmitted from an infectious patient to a susceptible host by droplet spread method.

iii) Contact with water/soil: The direct contact with contaminated water, soil, compost or decaying organic matter can transmit pathogens inhabiting them, for example

- The filariform larvae of Ancylostoma duodenale and Strongyloides stercoralis which abound in damp soil may penetrate the skin when in contact with faeces-polluted soil.
- The cercarial forms of Schistosoma haematobium, S. mansoni, and S. japonicum, may penetrate the skin of the person by contact with water containing them.

iv) Direct inoculation: The pathogen may be inoculated directly into the skin or mucosa through animal bites (rabies), or contaminated syringes (hepatitis B).

v) Through placenta: A mother can transmit infections to the unborn child via the placenta, for example gonorrhea and syphilis.

Indirect Transmission: Transfer of an infectious agent from a reservoir or infected host to another healthy host by suspended air particles, inanimate objects (vehicles), or animate intermediaries (vectors) is called as indirect transmission.

i) Air-borne transmission: Infectious agents are carried by air-borne dust or droplet nuclei suspended in the air. Droplet nuclei are dried residues of less than 5 microns in size. In contrast to droplets that fall to the ground within a few feet, droplet nuclei may remain suspended in the air for long periods of time and may be blown over great distances. For example, children have contracted measles at a physician's office after a visit of the child with measles because of the measles virus suspended in the air.

ii) Vehicle-borne transmission: It includes indirect transmission of an infectious agent through food, water, biological products (blood), and fomites (inanimate objects such as handkerchiefs, bedding, or surgical scalpels). The vehicle may provide an environment where the pathogen grows, multiplies, or produces toxin. For example,

- Improperly canned foods provide an environment that supports production of botulinum toxin by Clostridium botulinum.
- Ingestion of food and drink contaminated by infective form of parasite, e.g., cysts of Entamoeba histolytica; ova of Ascaris lumbricoides. Trichuris trichiura and Enterobius vermicularis; cyclops infected with the larval forms of Dracunculus medinensis can cause infections.
- Ingesting infective form of parasite in raw or undercooked meat of some intermediate hosts can transmit several diseases, such as ingestion of beef containing the larval stages of Taenia saginata, pork containing the larval forms of Taenia solium, (fish containing the plerocercoid larvae of Diphyllobothrium latum; and crab or cray fish containing the metacercarial form of Paragonimus westermani.

iii) Vector-borne transmission: The organisms, such as mosquitoes, fleas, and ticks may carry an infectious agent through purely mechanical means or may support growth and development of the agent. For example, houseflies carrying Shigella bacteria and other pathogens on their appendages are mechanical vectors. On the contrary, fleas which carry Yersinia pestis (the causative agent of plague) and, mosquitoes which transmit Plasmodium (the causative agent of malaria), etc. are biological vectors.

Q6. Write the detailed account of diagnostic tools used in disease manifestation.

Ans. The process of parasitic disease diagnosis seems reasonably complicated only on the basis of typical clinical features or just with simple physical examination. Therefore, the diagnosis of any disease and its severity level is all together dependent on the laboratory examination based on wellestablished protocols. Research and innovations in the field has resulted in the development and establishment of specific and

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