UNIT -3 CNIDARIA.

TDC IST SEM MAJOR : PAPER 1016

GENERAL CHARACTERISTICS AND CLASSIFICATION UPTOCLASSES.
METAGENESIS IN OBELIA
POLYMORPHISM IN CNIDARIA
CORALS AND CORAL REEFS

BY: DR. LUNA PHUKAN

Leuckart (1847) first coined the name Cnidaria. The term ‘Cnidaria’ is derived from two words; Gr. Knide=nettle and L. aria=like or connected with. Cnideraia are also known as Coelenterata. They have diverse colorful, radially symmetrical bodies which are known as the flower of the sea. The phylum Cnidaria contains more than 10,000 living species, among them, mostly are marine animals whereas only 20 species inhabit in freshwater.

The notable cnidarians include hydras, the corals, Portuguese men-of-war, jellyfish, sea anemones, sea whips, sea pens, and sea fans. Their variety, diverse colorful symmetry body forms, and complex life histories attract the scientists. They are diversely and abundantly distributed in tropical waters. They have calcareous skeletons which form the framework of the reefs and atolls in most tropical seas. The famous reef is the Great Barrier Reef which is more than 2000 km along the northeastern coast of Australia, made by the cnidarians.

General Characteristics Of Phylum Cnidaria

- They are aquatic organisms, mostly are marine and few inhabit in freshwater.
- They are diploblastic animals with a radially symmetrical body.
- The body wall consists of outer ectoderm and, inner endoderm or gastrodermis. In between the two layers, a non-cellular mesoglea is present.
- The body bears one central body cavity or gastrovascular cavity is known as coelenterons which gives the alternative name, Coelenterata.
- interstitial cells, endothelio-gland cells, nerve cells, and sensory cells.

- The representatives of cnidarians can make microscopic intracellular stinging capsules, known as nematocysts or cnidae, which also give the phylum name ‘Cnidaria’.
- The ectodermal layer contains different types of cells like endothelio-muscle cells, interstitial cells, glandulo-muscle cells, cnidoblasts or nematocysts, sensory cells, germ cells, and nerve cells.
- Endoderm or gastrodermis contains five types of cells such as endothelio-muscle cells or nutritive

- The interstitial cells have totipotent functions because they have the capability to produce any other cells like reproductive, glandular, specialized stinging cells, called cnidoblasts which secrete hypnotoxin (poison).
- They have incomplete alimentary canal because the anal opening is absent whereas the gut cavity contains a single opening which is known as mouth. In this case, mouth serves for ingestion and egestion.
- They are carnivorous and can digest all types of food. In this case, digestion is unique with extracellular digestion followed by intracellular digestion.
- They have a short and slender body with tentacles which encircle the mouth in one or two whorls. In this case, tentacles function for food-engulfing, capturing the prey and defense.

- In nature, they have two distinct forms such as polyp and medusa (Polymorphism). In this case, polyps are sessile (asexual stage) while medusa is free-swimming (sexual stage).

- In their body, circulatory, respiratory and excretory systems are absent. Through general body surface, gaseous exchange and excretion occur.

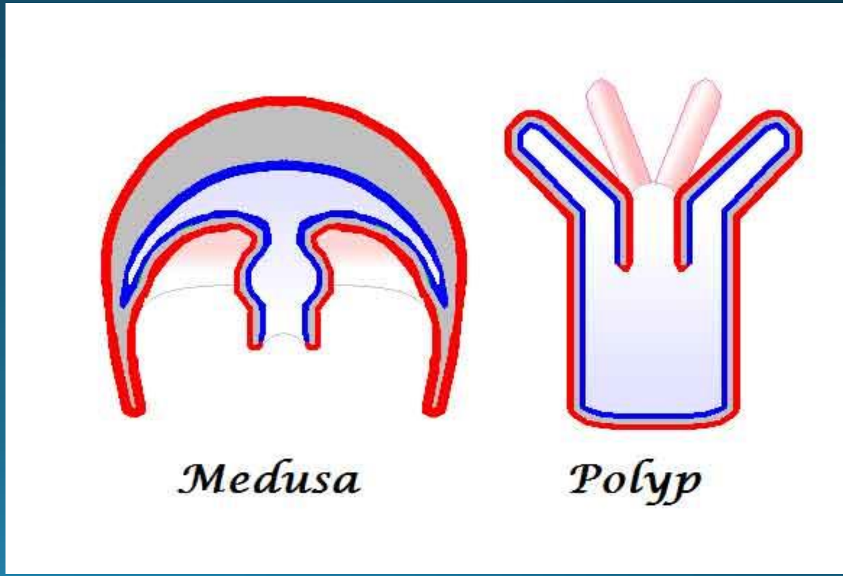
- They can move with the help of smooth muscle fibrils in the epithelia or ectoderm. Tentacles also play a vital role in the movement.

- The nervous system is poorly developed which makes the network of nerve fibers in the body walls and the tentacles.

- The body bears single or complicated sensory organs with eyespots called statocysts.

- They reproduce either asexual by external budding or sexual by the formation of ova and sperm.

- They show alternation of generation (metagenesis) in their life cycle, in which asexual colonial polypoid generation alternate with sexual free-swimming medusoid generation.
- Fertilization is internal or external and development is indirect with a larval stage. In this case, planula larva is a common but ephyra larva is found in some animals.



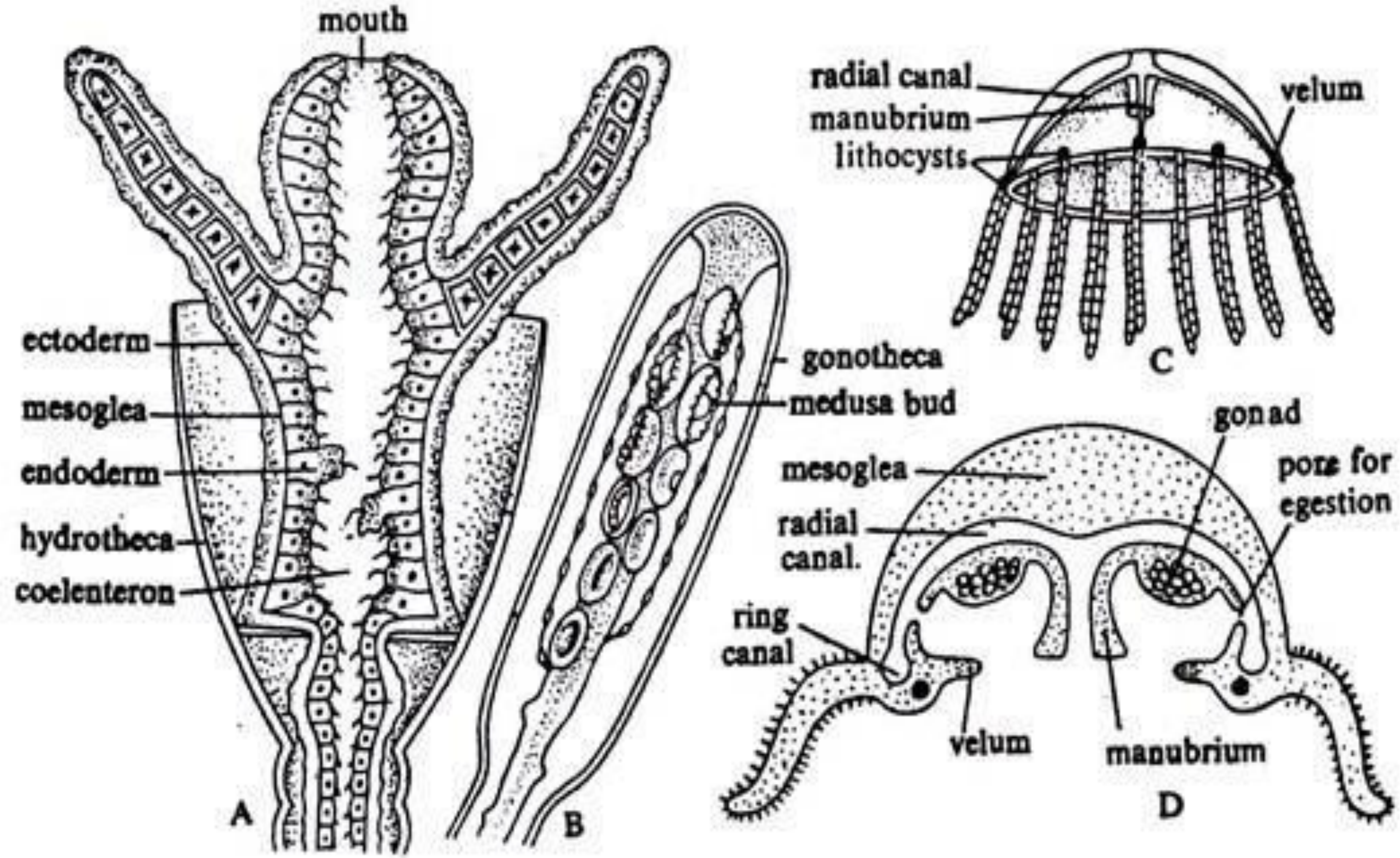


Fig. 1.37 : Enlarged view of certain zooids of *Obelia* colony. A. Gastrozooid, B. Blastostyle, C. Medusa, D. Sectional view of medusa.

Classification of Phylum Cnidaria/Coelenterata

The phylum Cnidaria is composed of the following three classes on the basis of development of zooids:

Hydrozoa (hydrozoans);
Scyphozoa (scyphozoans);
Anthozoa (anthozoans);

Class-1: Hydrozoa (Hydra; water; zoon: animal)

They are mostly marine organisms but some inhabit freshwater.
Some species inhabit solitary and some form colony.

- They are diploblastic animals. Between two layers, mesoglea is present which is simple and acellular.
- The gonads are ectodermal in origin.
- They show asexual polyp stage and sexual medusa stage in their life cycle. In this case, the polyp stage is the dominant and medusa possesses true velum.
- The body contains statocysts to maintain equilibrium.
- Examples: Hydra oligactis, Obelia bidentata, Physalia physalis (portuguese man of war) etc.

HYDRA

Class 2: Scyphozoa

This class includes about 200 described species..

- The body length of the most jellies range from 2 to 40 cm but the largest scyphozoan species (Cyanea capillata) can reach up to two meters in diameter.
- They are completely marine organisms.
- They are free-swimming and are solitary.
- Thick jelly-like cellular mesoglea is present.
- Polyp stage is undeveloped or absent.
- Bell or umbrella-shaped medusa is present.

- Medusa stage is prominent and it does not have velum.
- To maintain equilibrium, they have tentaculocytes.
- In their life cycle, the larval stage is present (Ephyra larva).
- Gonads are originated from endoderm.
- Example: Aurelia aurita (Jelly fish), Rhizostoma pulmo etc.

JELLY FISH

Class-3: Anthozoa (Anthos: flower; zoios: animal ‘flower-like animals')

- The class Anthozoa contains about 6100 described species.
- They have cylindrical–shaped body and are attached directly to a submerged substrate.
-
- They are completely marine organisms.
- They inhabit to form a colony and some are solitary.
- Cellular mesoglea region is present which consists of fibrous connective tissue and amoeboid cells.
- In their life cycle, only the polyp stage is present.

- Gonads are originated from endoderm. In tropical seas, they form reefs by secreting calcium carbonate ($CaCO_3$).
- They give rise to a free-swimming planula larva in their life cycle.
- Example: Gorgonia ventalina (the purple sea fan), Pennatula phosphorea (common Sea Pen), Metridium parvulum (sea anemone), etc

Anthozoa Colony

Concluding Remarks

The representatives of Phylum Cnidaria have radial or biradial symmetrical body. About 99 % cnidarians are marine species and few inhabit in freshwater. They are diploblastic animals and have a more complex level of organization than Porifera. In their body wall, outer ectoderm, inner endoderm layers are present but in between these two layers non-cellular mesoglea is found. In their life cycle, they show two distinct morphological forms such as polypoid and medusoid.

METAGENESIS IN OBELIA

METAGENESIS The life cycle of Obelia represents a remarkable example of alternation of generation where the asexual and sessile phase of Obelia reproduces asexually by budding and gives rise to sexual and free-swimming medusa. ... This phenomenon of alternation between two diploid phases is termed as metagenesis.

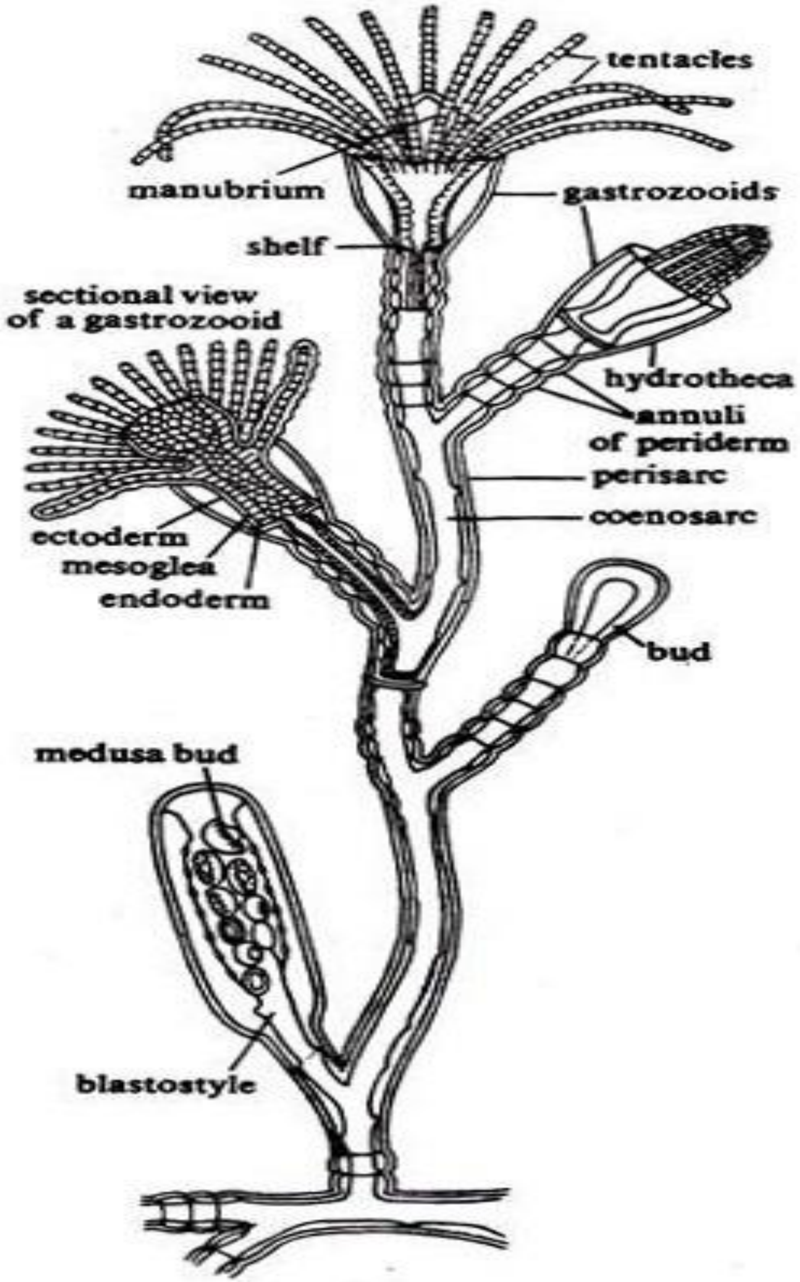


Fig. 1.36 : Enlarged view of an *Obelia* colony.

The following points highlight the top two phases of obelia. The phases are:

1. Hydroid or Polyp Phase
2. Medusoid Phase.

Obelia: Phase # 1. Hydroid or Polyp Phase:

Hydroid stage of Obelia is in a colonial form. It is a branched filament like structure and remains attached with the substratum. This colony is polymorphic, i.e., number of individuals or zooids are present which are morphologically as well as functionally different from each other.

The polyp is composed of following structures:

(a) Hydrorhiza and Hydrocaulus:

Obelia colony is constituted of two portions, the horizontal portion is called the Hydrorhiza and the vertical portion bearing the zooids is named as the Hydrocaulus .

(b) Gastro-zooid or Trophozooid or Nutritive Zooid:

Most of the zooids present in the hydroid stage of Obelia are the Gastro-zooid . They are specially designated to perform nutritive function and feed the whole colony. Each Gastro-zooid has a short tube-like body having at its distal end a conical projection called the hypostome or manubrium.

The mouth is situated at the terminal end of the manubrium. Surrounding the manubrium there is a circlet of about twenty four solid tentacles.

(c) Blastostyle or Gonozooid or Reproductive Zooid:

These particular types of zooids are few in number in comparison to the number of gastro-zooids. Each blastostyle has a long cylindrical body without mouth and tentacles . The coelenteron is greatly reduced. It is enclosed by a transparent covering called gonotheca. The lateral wall of the body gives off small lateral buds called the medusa-buds.

Obelia: Phase # 2. Medusoid Phase:

Medusa develops as hollow offshoot of the blastostyle. When fully-formed, it assumes the appearance of an umbrella with a convex surface by which the medusa was attached with the blastostyle . This convex side is called the ex-umbrella and the concave side of the umbrella is known as the sub-umbrella.

From the centre of the sub- umbrellar surface emerges a hanging tube called the manubrium bearing a square mouth at its terminal end . The edge of the umbrella gives rise to a very short circular shelf called the velum. At the junction of the exumbrellar side and velum there is a circlet of tentacles.

The number of tentacles is sixteen in a newly-formed stage but the number may increase with age. At the bases of alternate tentacles there lies a sense organ in the form of lithocyst or marginal sense organ . Each lithocyst has a very small spherical sac-like body that encloses a central calcareous mass and sensory cells. These sense organs regulate and co-ordinate the movement of the organism.

The mouth leads into the coelenteron lodged inside the manubrium. From the base of the coelenteron emerge four equidistant radial canals, which ultimately open into a ring canal situated at the margin of the body of the umbrella. Through these canals food matters are conveyed to the different parts of the body.

The whole organisation of the body of the medusa exhibits distinct radial symmetry. The medusae are unisexual (dioecious). Gonads are ectodermal in origin and remain in close association with the radial canals towards the subumbrellar surface. They have rounded appearance and are four in number. Both the male and female gonads are similar externally.

Life-history:

The male gametes or spermatozoa, after maturation, are liberated into the water and one spermatozoa fertilizes a female gamete or ovum and thus results into the formation of a zygote.

The single-celled zygote divides repeatedly and the daughter cells reorganize to form stages like blastula and gastrula in due course. Finally, a larval form—the planula larva is produced.

Planula Larva:

The planula larva has an elongated and ovoid appearance. The outer layer of the body is composed of ciliated ectodermal cells and the inner layer is made of endodermal cells. Mouth is absent. It is free-swimming and contains a cavity which is the primordial coelenteron After a brief free-swimming existence, the planula larva settles down, fixes itself to the substratum by one pole and transforms itself into the next stage—the hydrula stage.

Hydrula Stage:

The fixed end of this form is designated as the aboral end and the free or oral end develops a manubrium and a circlet of tentacles. Then a mouth is formed at the centre of the manubrium. The hydrula, thus formed, gives out lateral buds and transforms into an Obelia colony and exhibits typical instance of metagenesis.

Metagenesis in Obelia:

Amongst Cnidarians, Obelia shows excellent metagenesis. The Obelia colony represents the hydroid or asexual stage (2n), which produces medusa- buds (2n) by budding (Fig. 2.89 and 2.90). These medusa-buds subsequently transform into full-fledged medusae. The medusae represent the sexual stage and possess male or female gonads (2n).
The male and the female gametes (n) are produced in the respective gonads. Mature male and female gametes unite and results into the formation of zygote (2n), which in turn passes through the usual developmental stages.

The developmental process in Obelia is indirect and intervened by the presence of larval forms, which gives rise to the Obelia colony. So in the life-cycle of Obelia there is a distinct alternation of two phases .

One phase is completely engaged in the growth of the colony, the asexual phase or polyp with diploid (2n) genetic composition, while the other phase is engaged in producing gametes the sexual phase or medusae, which is also diploid (2n) in genetic composition and produce haploid (n) gametes . Such a phenomenon is called metagenesis.

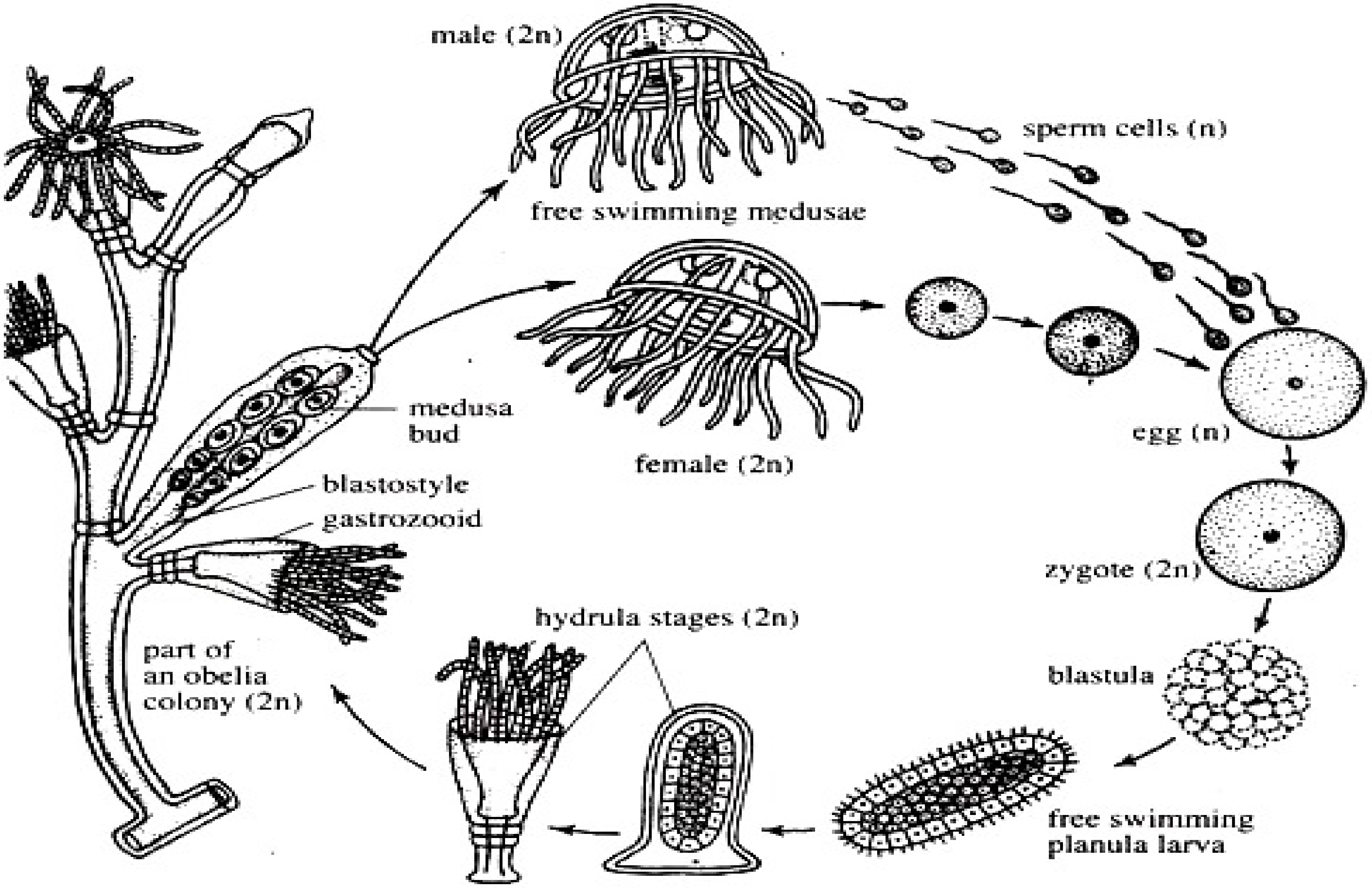


Fig. 2.89 : Life-history of *Obelia*. Note the presence of asexual and sexual phases in the life history. The free swim-

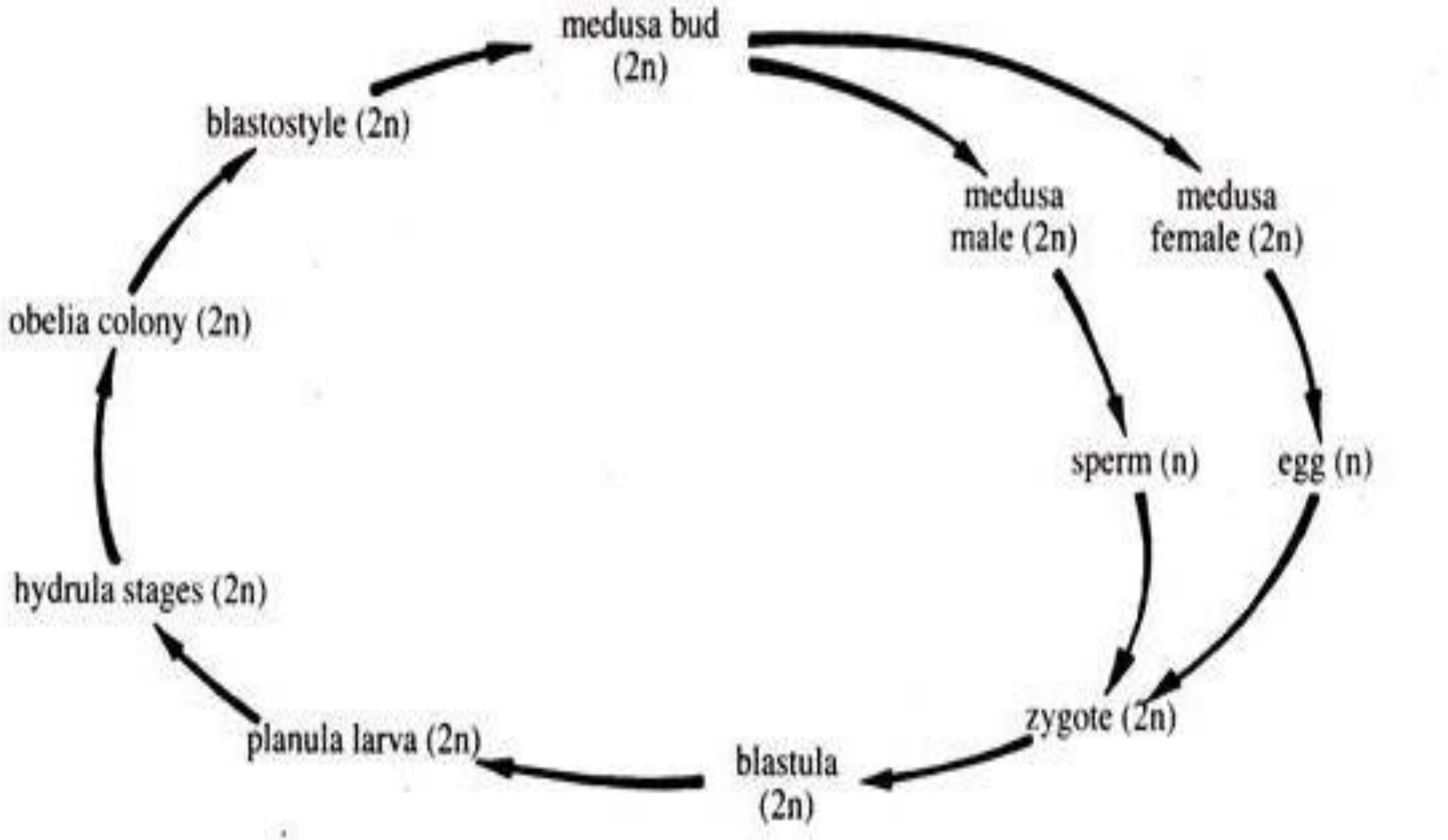


Fig. 2.90 : Life-cycle of *Obelia*. Note the chromosome constitution of different life stages for understanding metagenesis.

Metagenesis is the result of polymorphism. Polymorphism is the phenomenon of division of labour, i.e. different functions are assigned to different individuals, rather than to the parts of organism.

2. Some authors considered Metagenesis and alternation of generation as same thing, but in strict sense both are different. The alternation of generation is related with two forms which are genotypically different, one is diploid and other is haploid.

The diploid form can be produced by either sexual or asexual methods, but haploid form is produced by asexual method only. So the alternation of generation is a phenomena in which a diploid individual alters with the haploid individual, both may be isomorphic or an isomorphic, but can exist their life without the other form, mean both form are not obligatory to complete the life cycle

. But in case of Metagenesis the existing individual are genetically same, but they differ morphologically and functionally. Both forms are complementary to each other to complete their life cycle and life activities.

4. METAGENESIS The life cycle of Obelia represents a remarkable example of alternation of generation where the asexual and sessile phase of Obelia reproduces asexually by budding and gives rise to sexual and free-swimming medusa.

. The medusa reproduces sexually and forms new polyps. Thus, a diploid asexual hydroid phase alternates with another diploid sexual medusoid phase. This phenomenon of alternation between two diploid phases is termed as metagenesis

POLYMORPHISM Thus, the life cycle of Obelia includes three distinct types of zooids; a) Nutritive polyps – hydranths b) Asexual reproductive polyps – blastostyles c) Sexual reproductive polyps – medusa This phenomenon, where Obelia is represented by structurally and functionally different individuals, is called polymorphism. Initially the colony of Obelia is represented by only two forms, gastrozooids and blastozooids and is called dimorphic. Later, when gonophores develop on the blastozooids by the process of budding, the colony is considered trimorphic represented by three kinds of zooids

POLYMORPHISM IN CNIDARIA

Polymorphism. Polymorphism refers to the occurrence of structurally and functionally more than two different types of individuals within the same organism. It is a characteristic feature of Cnidarians, particularly the polyp and medusa forms, or of zooids within colonial organisms like those in Hydrozoa.

Polymorphism: Definition, Causes and Significance | Cnidarians

Definition of Polymorphism:

Polymorphism may be defined as the "phenomenon of existence of different physiological and morphological forms represented by an extensive range of variation within a single species".

It may be defined in another way, polymorphism means "the existence of individuals (zooids) of a single species in more than one forms and functions."

Causes of Polymorphism:

Polymorphism is due to the division of labour, diversification of forms and specialization. Two general types of interactions, viz., co-operation and disoperation are exhibited by the members of an animal association.

In the colonial forms, disoperation ceases gradually and is replaced by co-operation. Finally the whole colony appears as a single individual, and the zooids function collectively for the interest of the colony (Barrington 1979).

Basic Units of Polymorphism:

All forms of zooids can be divided into two fundamental forms which can be derived from each other.

(A) Polyp form (L. Polypus = polyp) (Fig. 12.32A):

(i) Sedentary tubular form with one end closed.

(ii) Free conical end (preoral end) bearing hypostome, mouth and tentacles.

(iii) Aboral end fixed.

(iv) Mouth situated on hypostome leading to coelenteron.

(B) Medusoid form (Gk. Medousa = one who rules) (Fig. 12.32B):

(i) Umbrella-shaped with convex exumbrella and ventral concave subumbrellar surface.
(ii) Subumbrellar surface with mouth and manubrium.
(iii) Radial and circular canals present.
(iv) Marginal tentacles are present.
(v) Presence of gonads.
(vi) A velum is often present.
(vii) Free-swimming form

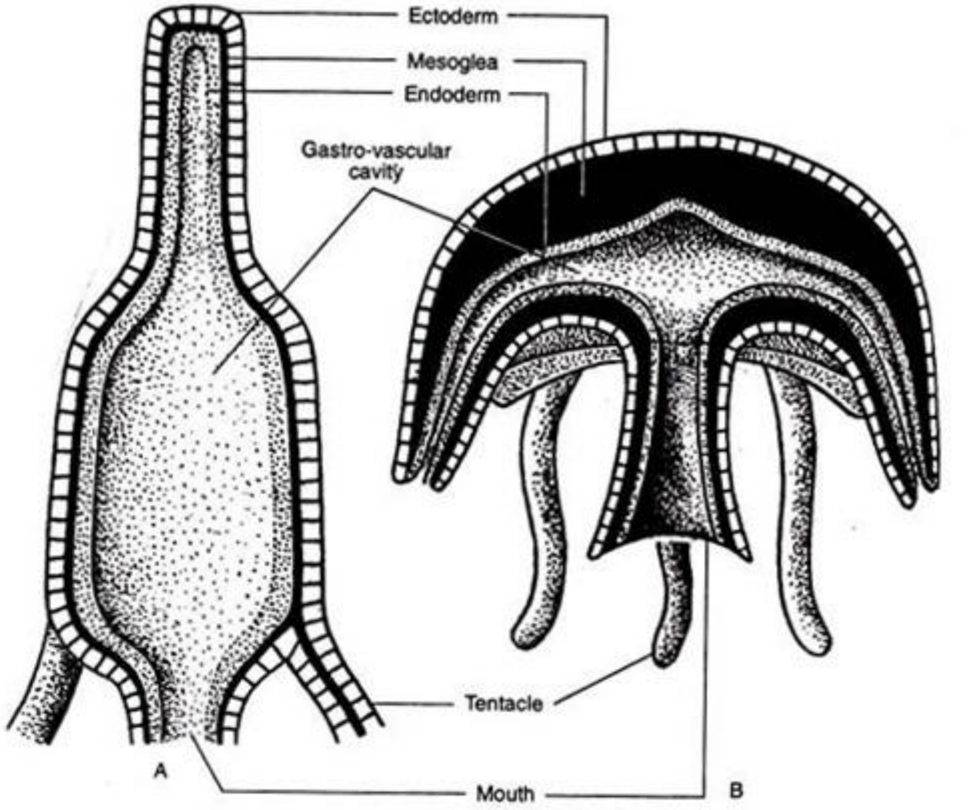


Fig. 12.32: Primary body forms of cnidarians : polyp (A) and medusa (B) in diagrammatic longitudinal sections. Polyp is drawn in invested state.

Polyps and medusae are considered as homologous structures and can be theoretically derived from a sac-like body. Possessing of manubrium and mouth points to the basic similarity (Hyman, 1940).

These two forms alternate with each other in the life history of a typical cnidarian—the polyp producing medusa asexually and the medusa producing polyp sexually.

Origin of Polymorphism:

Polymorphism in cnidarians is virtually regarded to be the division of labour, where different zooids perform diverse functions.

As regards the origin of polymorphism in cnidarians, the following theories have been advanced:

Poly-organ theory:

The main supporters of the theory are Huxley, Metschnikoff and Eschscholtz. They regard that each poly-morphic colony is an individual and the polyps or medusae, which are budded off from it, are the organs.

Poly-person theory:

The supporters of this theory are Vogt, Leuckart, Gegenbaur, Cuhn and Kukenthal. This theory suggests that cnidarian colony is constituted of independent and separate individuals which remain in organic connection with one another. According to this view each zooid is a separate individual, where some portions may be either lost or obliterated in course of time.

Medusa theory:

This theory is forwarded by Haeckel, Balfour and Sedgwick. The theory advocates that the primitive zooid of polymorphic colony was, with all probabilities, a medusa which produced other medusae by the process of budding.

These medusae possess the power of locomotion as well as the power of reproduction. In this view many organs of the colony are nothing more than the parts of such medusoid individuals which have subsequently shifted their attachments from the original medusa.

This concept makes a compromise between the two previously described theories. It agrees with the second theory in asserting the colonial nature and also admits that asexual reproduction and specialisation of certain parts of the colony, as advocated in the first theory.

Theory of neoteny (supported by A. C. Hardy):

Garstang first postulated the idea of the neotenous retention of larval characters and the members of Siphonophora giving rise to polymorphism.

Significance of Polymorphism:

1. Polymorphism is intimately associated with life-history. The life cycle is simple in the monomorphic forms (e.g., Hydra). With the advent of polymorphism reproductive powers are divided. The polyp is capable only of asexual reproduction while sexual reproduction is confined to the gonophores. Thus arises the alternation of generation or metagenesis.

2. Polymorphism is also concerned with the division of labour. So polyp are mainly associated with the function of feeding, testing, protection and also asexual reproduction while medusa is concerned with sexual reproduction.

CORALS AND CORAL REEF

CORALS: Corals are invertebrate animals belonging to a large group of colourful and fascinating animals called Cnidaria. Other animals in this group that you may have seen in rock pools or on the beach include jelly fish and sea anemones. Although Cnidarians exhibit a wide variety of colours, shapes and sizes, they all share the same distinguishing characteristics; a simple stomach with a single mouth opening surrounded by stinging tentacles. Each individual coral animal is called a polyp, and most live in groups of hundreds to thousands of genetically identical polyps that form a ‘colony’. The colony is formed by a process called budding, which is where the original polyp literally grows copies of itself.

Coral are generally classified as either “hard coral” or “soft coral”. There are around 800 known species of hard coral, also known as the ‘reef building’ corals. Soft corals, which include seas fans, sea feathers and sea whips, don’t have the rock-like calcareous skeleton like the others, instead they grow wood-like cores for support and fleshy rinds for protection. Soft corals also live in colonies, that often resemble brightly coloured plants or trees, and are easy to tell apart from hard corals as their polyps have tentacles that occur in numerals of 8, and have a distinctive feathery appearance. Soft corals are found in oceans from the equator to the north and south poles, generally in caves or ledges. Here, they hang down in order to capture food floating by in the currents that are usually typical of these places.

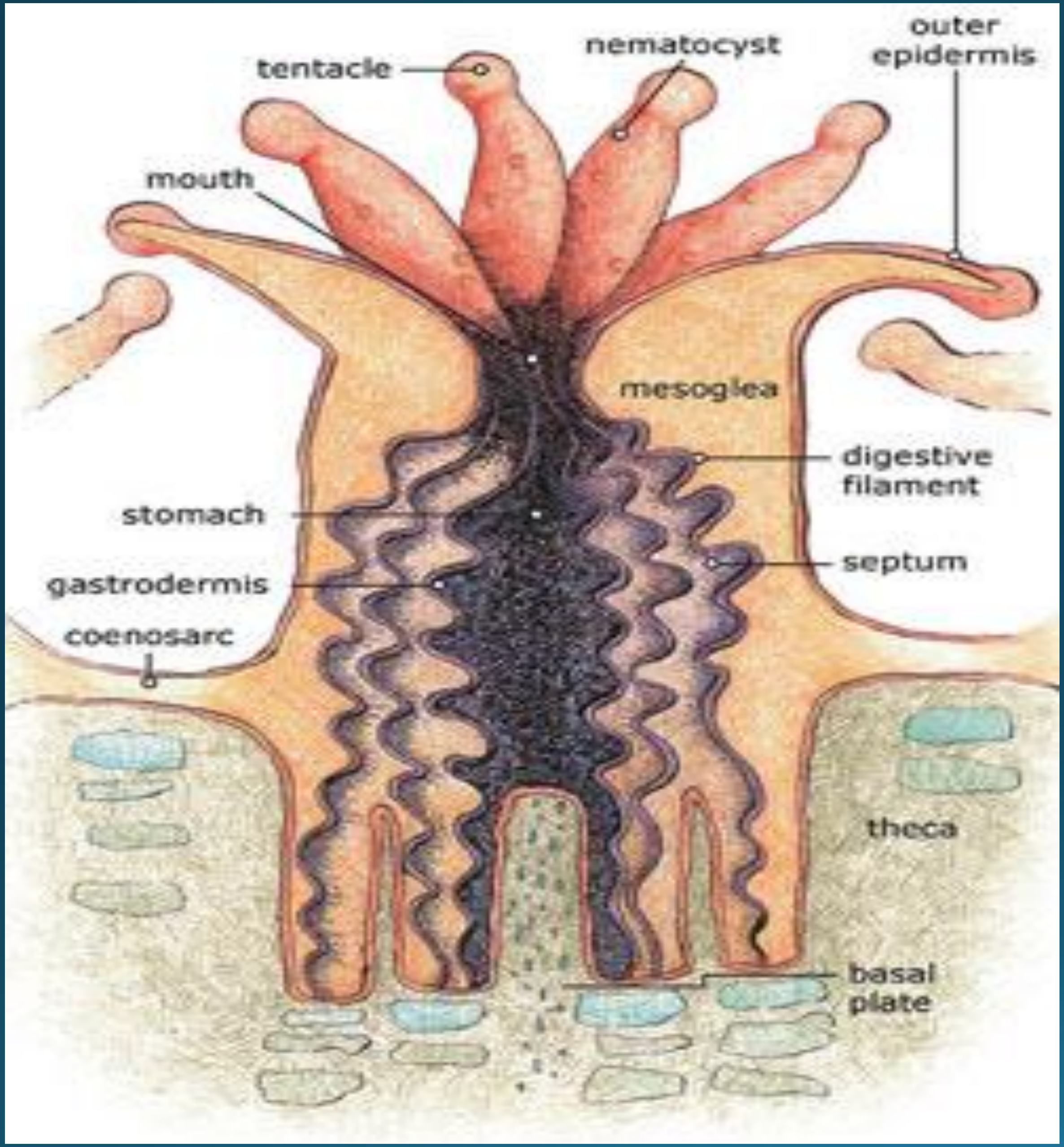
CLASSIFICATION: Presently, corals are classified as species of animals within the sub-classes Hexacorallia and Octocorallia of the class Anthozoa in the phylum Cnidaria.

Hexacorallia includes the stony corals and these groups have polyps that generally have a 6-fold symmetry.

Octocorallia includes blue coral and soft corals and species of Octocorallia have polyps with an eightfold symmetry, each polyp having eight tentacles and eight mesenteries. The group of corals is paraphyletic because the sea anemones are also in the sub-class Hexacorallia.

Anatomy

For most of their life corals are sessile animals of colonies of genetically identical polyps. Each polyp varies from millimeters to centimeters in diameter, and colonies can be formed from many million individual polyps. Stony coral, also known as hard coral, polyps produce a skeleton composed of calcium carbonate to strengthen and protect the organism. This is deposited by the polyps and by the coenosarc, the living tissue that connects them.



Anatomy of a polyp

The polyps sit in cup-shaped depressions in the skeleton known as corallites. Colonies of stony coral are very variable in appearance; a single species may adopt an encrusting, plate-like, bushy, columnar or massive solid structure, the various forms often being linked to different types of habitat, with variations in light level and water movement being significant

The body of the polyp may be roughly compared in a structure to a sac, the wall of which is composed of two layers of cells. The outer layer is known technically as the ectoderm, the inner layer as the endoderm. Between ectoderm and endoderm is a supporting layer of gelatinous substance termed mesoglea, secreted by the cell layers of the body wall.[8] The mesoglea can contain skeletal elements derived from cells migrated from ectoderm.

The sac-like body built up in this way is attached to a hard surface, which in hard corals are cup-shaped depressions in the skeleton known as corallites. At the center of the upper end of the sac lies the only opening called the mouth, surrounded by a circle of tentacles which resemble glove fingers.

The tentacles are organs which serve both for the tactile sense and for the capture of food Polyps extend their tentacles, particularly at night, often containing coiled stinging cells (cnidocytes) which pierce, poison and firmly hold living prey paralysing or killing them. Polyp prey includes plankton such as copepods and fish larvae.

Longitudinal muscular fibers formed from the cells of the ectoderm allow tentacles to contract to convey the food to the mouth. Similarly, circularly disposed muscular fibres formed from the endoderm permit tentacles to be protracted or thrust out once they are contracted.In both stony and soft corals, the polyps can be retracted by contracting muscle fibres, with stony corals relying on their hard skeleton and cnidocytes for defence. Soft corals generally secrete terpenoid toxins to ward off predators.

In most corals, the tentacles are retracted by day and spread out at night to catch plankton and other small organisms. Shallow water species of both stony and soft corals can be zooxanthellate, the corals supplementing their plankton diet with the products of photosynthesis produced by these symbionts.[7] The polyps interconnect by a complex and well-developed system of gastrovascular canals, allowing significant sharing of nutrients and symbionts

Soft corals

Soft corals have no solid exoskeleton as such. However, their tissues are often reinforced by small supportive elements known as "sclerites" made of calcium carbonate. The polyps of soft corals have eight-fold symmetry.

Soft corals vary considerably in form, and most are colonial. A few soft corals are stolonate, but the polyps of most are connected by sheets of tissue called coenosarc, and in some species these sheets are thick and the polyps deeply embedded in them. Some soft corals encrust other sea objects or form lobes. Others are tree-like or whip-like and chem a central axial skeleton embedded at its base in the matrix of the supporting branch.[10] These branches are composed either of a fibrous protein called gorgonin or of a calcified material.

Stony corals

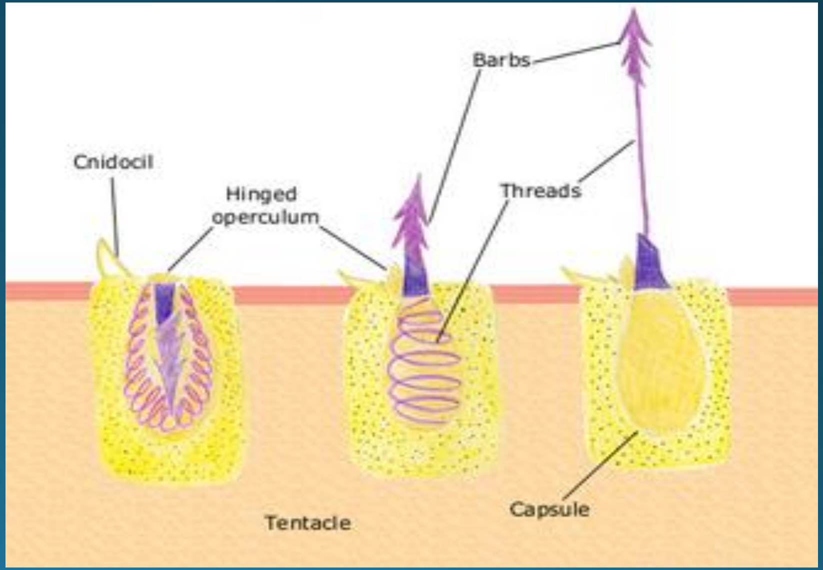
The polyps of stony corals have six-fold symmetry. In stony corals the polyps are cylindrical and taper to a point, but in soft corals they are pinnate with side branches known as pinnules. In some tropical species these are reduced to mere stubs and in some they are fused to give a paddle-like appearance

Coral skeletons are biocomposites (mineral + organics) of calcium carbonate, in the form of calcite or aragonite. In scleractinian corals, "centers of calcification" and fibers are clearly distinct structures differing with respect to both morphology and chemical compositions of the crystalline units.

Feeding

Polyps feed on a variety of small organisms, from microscopic zooplankton to small fish. The polyp's tentacles immobilize or kill prey using stinging cells called nematocysts. These cells carry venom which they rapidly release in response to contact with another organism

Discharge mechanism of a stinging cell (nematocyst)



A dormant nematocyst discharges in response to nearby prey touching the trigger (Cnidocil). A flap (operculum) opens and its stinging apparatus fires the barb into the prey. The venom is injected through the hollow filament to immobilise the prey; the tentacles then manoeuvre the prey into the stomach. Once the prey is digested the stomach reopens allowing the elimination of waste products and the beginning of the next hunting cycle

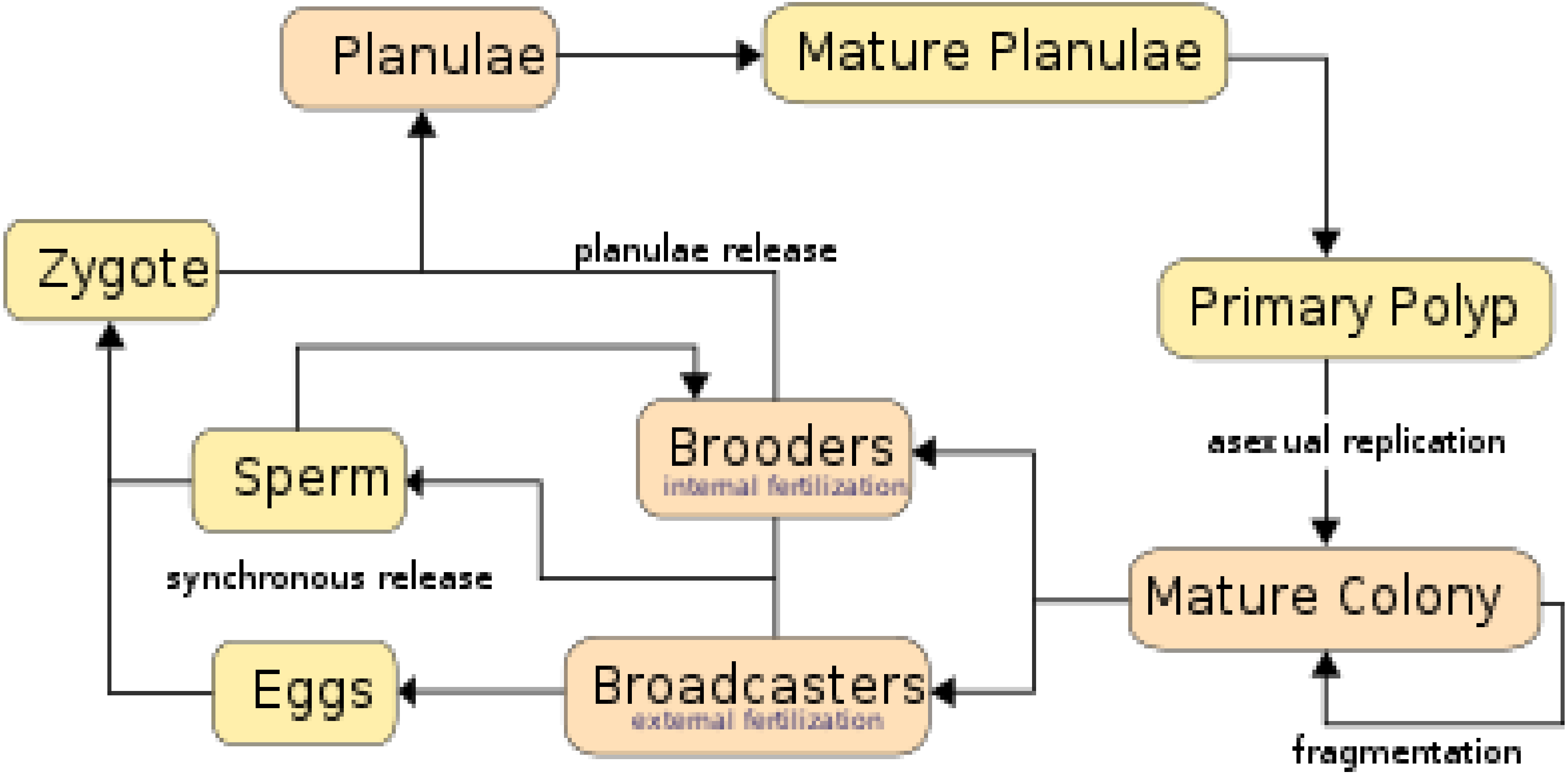
Reproduction

Corals can be both gonochoristic (unisexual) and hermaphroditic, each of which can reproduce sexually and asexually. Reproduction also allows coral to settle in new areas. Reproduction is coordinated by chemical communication.

Sexual

Life cycles of broadcasters and brooders

Corals predominantly reproduce sexually. About 25% of hermatypic corals (stony corals) form single sex (gonochoristic) colonies, while the rest are hermaphroditi



Life cycles of broadcasters and brooders

Broadcasters

About 75% of all hermatypic corals "broadcast spawn" by releasing gametes—eggs and sperm—into the water to spread offspring. The gametes fertilize at the water's surface to form a microscopic larva called a planula, typically pink and elliptical in shape. A typical coral colony forms several thousand larvae per year to overcome the odds against formation of a new colony. Synchronous spawning is very typical on the coral reef, and often, even when multiple species are present, all corals spawn on the same night. This synchrony is essential so male and female gametes can meet. Corals rely on environmental cues, varying from species to species, to determine the proper time to release gametes into the water. The cues involve temperature change, lunar cycle, day length, and possibly chemical signalling. Synchronous spawning may form hybrids and is perhaps involved in coral speciation.The immediate cue is most often sunset, which cues the release.The spawning event can be visually dramatic, clouding the usually clear water with gametes

Brooders

Brooding species are most often ahermatypic (not reef-building) in areas of high current or wave action. Brooders release only sperm, which is negatively buoyant, sinking on to the waiting egg carriers who harbor unfertilized eggs for weeks. Synchronous spawning events sometimes occur even with these species.After fertilization, the corals release planula that are ready to settle

Planulae

The time from spawning to larval settlement is usually two to three days, but can occur immediately or up to two months.Broadcast-spawned planula larvae develop at the water's surface before descending to seek a hard surface on the benthos to which they can attach and begin a new colony. The larvae often need a biological cue to induce settlement such as specific crustose coralline algae species or microbial biofilms.High failure rates afflict many stages of this process, and even though thousands of eggs are released by each colony, few new colonies form. During settlement, larvae are inhibited by physical barriers such as sediment, as well as chemical (allelopathic) barriers. The larvae metamorphose into a single polyp and eventually develops into a juvenile and then adult by asexual budding and growth.

Asexual

Within a coral head, the genetically identical polyps reproduce asexually, either by budding (gemmation) or by dividing, whether longitudinally or transversely.

Budding involves splitting a smaller polyp from an adult.[26] As the new polyp grows, it forms its body parts. The distance between the new and adult polyps grows, and with it, the coenosarc (the common body of the colony). Budding can be intratentacular, from its oral discs, producing same-sized polyps within the ring of tentacles, or extratentacular, from its base, producing a smaller polyp

Colony division

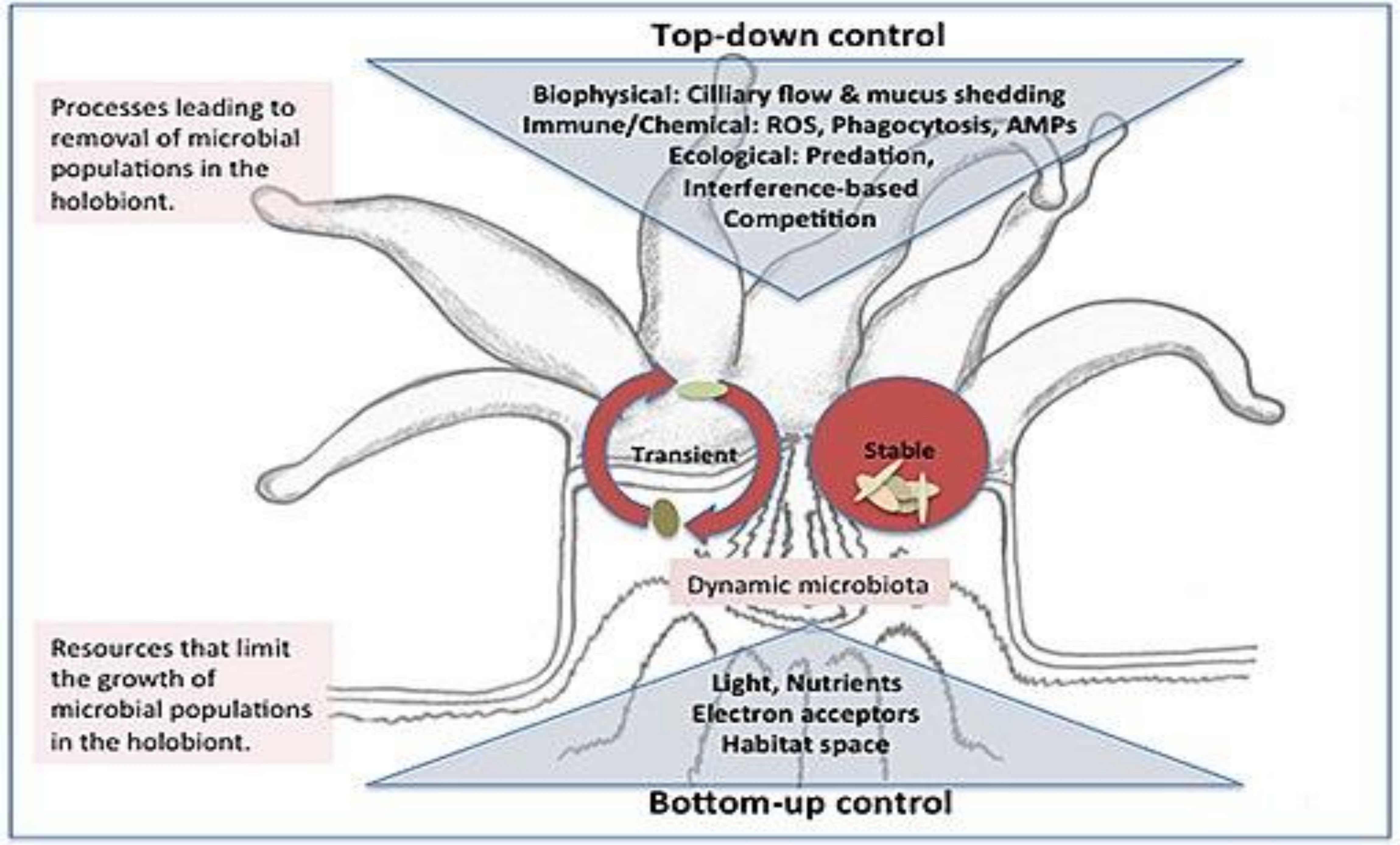
Whole colonies can reproduce asexually, forming two colonies with the same genotype. The possible mechanisms include fission, bailout and fragmentation. Fission occurs in some corals, especially among the family Fungiidae, where the colony splits into two or more colonies during early developmental stages. Bailout occurs when a single polyp abandons the colony and settles on a different substrate to create a new colony. Fragmentation involves individuals broken from the colony during storms or other disruptions. The separated individuals can start new colonies

Coral microbiome

Coral holobiont

Reef-building corals are well-studied holobionts that include the coral itself together with its symbiont zooxanthellae (photosynthetic dinoflagellates), as well as its associated bacteria and viruses. Co-evolutionary patterns exist for coral microbial communities and coral phylogeny

FIG:Top- down and bottom-up control of microbiota structure in the coral holobiont .Stable microbes may be introduced to the holobiont through horizontal or vertical transmission and persist in



Top-down control
Biophysical: Cilliary flow & mucus shedding
Immune/Chemical: ROS, Phagocytosis, AMPs
Ecological: Predation,
Interference-based
Competition
Processes leading to removal of microbial populations in the holobiont.
Transient
Stable
Dynamic microbiota
Resources that limit the growth of microbial populations in the holobiont.
Light, Nutrients
Electron acceptors
Habitat space
Bottom-up control

ecological niches within the coral polyp where growth (or immigration) rates balance removal pressures from biophysical processes and immune or ecological interactions. Transient microbes enter the holobiont from environmental sources (e.g., seawater, prey items, or suspension feeding) and removal rates exceed growth/immigration rates such that a dynamic and high diversity microbiota results. Transient and stable populations compete for resources including nutrients, light and space and the outcome of resource-based competition (bottom up control) ultimately determines population growth rate and thus ability to persist when subject to removal. Whether a population is categorized as stable or transient may depend on the timeframe considered.

AMP = antimicrobial peptides, ROS = reactive oxygen species

CORAL REEF

A coral reef is an underwater ecosystem characterized by reef-building corals. Reefs are formed of colonies of coral polyps held together by calcium carbonate. Most coral reefs are built from stony corals, whose polyps cluster in groups.

Formation

Most coral reefs were formed after the Last Glacial Period when melting ice caused sea level to rise and flood continental shelves. Most coral reefs are less than 10,000 years old. As communities established themselves, the reefs grew upwards, pacing rising sea levels. Reefs that rose too slowly could become drowned, without sufficient light. Coral reefs are found in the deep sea away from continental shelves, around oceanic islands and atolls. The majority of these islands are volcanic in origin. Others have tectonic origins where plate movements lifted the deep ocean floor.

The Structure and Distribution of Coral Reefs:

Charles Darwin set out his theory of the formation of atoll reefs, an idea he conceived during the voyage of the Beagle. He theorized that uplift and subsidence of Earth's crust under the oceans formed the atolls.

Darwin set out a sequence of three stages in atoll formation. A fringing reef forms around an extinct volcanic island as the island and ocean floor subsides. As the subsidence continues, the fringing reef becomes a barrier reef and ultimately an atoll reef.

Darwin predicted that underneath each lagoon would be a bedrock base, the remains of the original volcano. Subsequent research supported this hypothesis. Darwin's theory followed from his understanding that coral polyps thrive in the tropics where the water is agitated, but can only live within a limited depth range, starting just below low tide. Where the level of the underlying earth allows, the corals grow around the coast to form fringing reefs, and can eventually grow to become a barrier reef.

Where the bottom is rising, fringing reefs can grow around the coast, but coral raised above sea level dies. If the land subsides slowly, the fringing reefs keep pace by growing upwards on a base of older, dead coral, forming a barrier reef enclosing a lagoon between the reef and the land. A barrier reef can encircle an island, and once the island sinks below sea level a roughly circular atoll of growing coral continues to keep up with the sea level, forming a central lagoon

Material

As the name implies, coral reefs are made up of coral skeletons from mostly intact coral colonies. As other chemical elements present in corals become incorporated into the calcium carbonate deposits, aragonite is formed. However, shell fragments and the remains of coralline algae such as the green-segmented genus Halimeda can add to the reef's ability to withstand damage from storms and other threats. Such mixtures are visible in structures such as Eniwetok Atoll

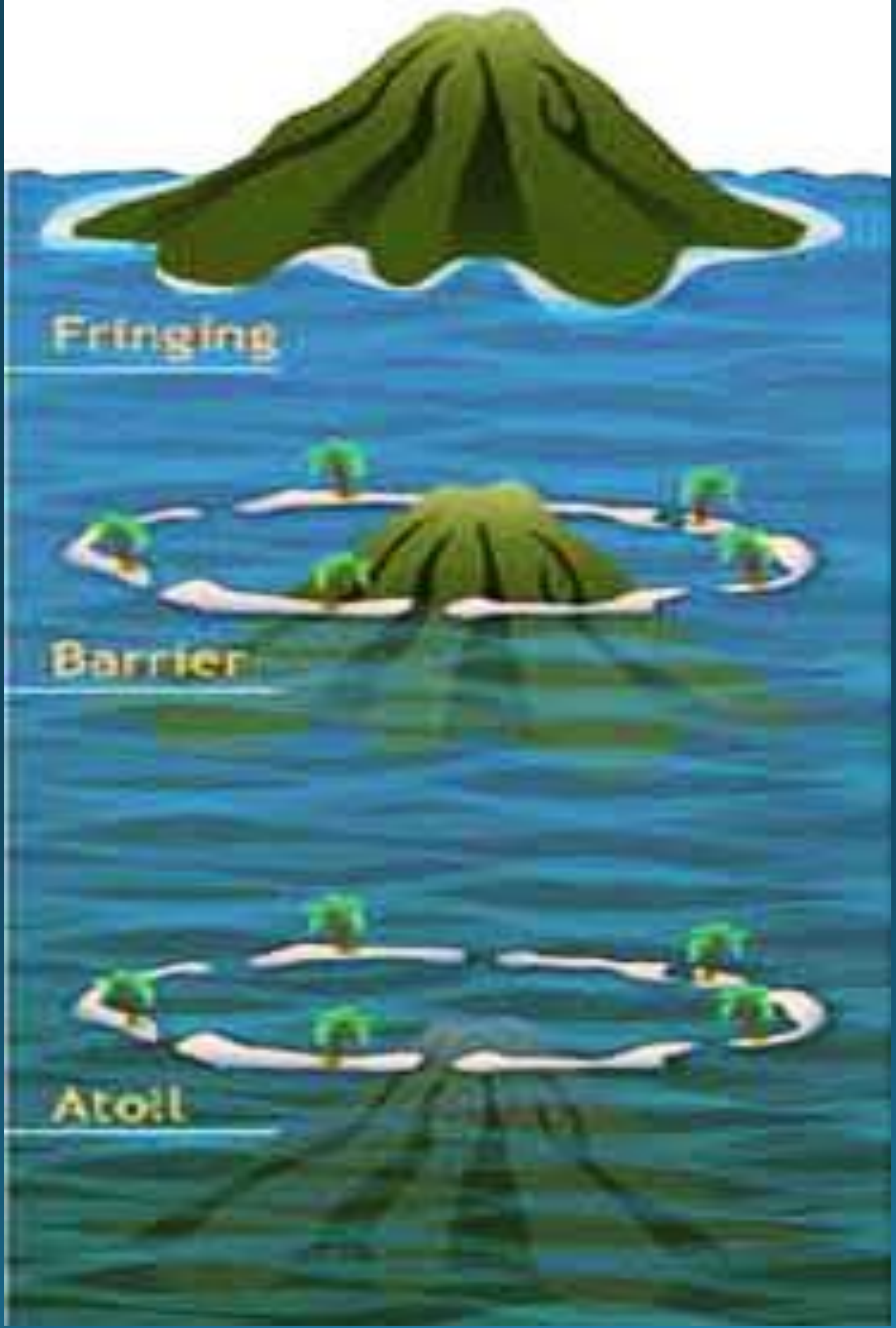
Types

Charles Darwin who originally classified coral reefs as to their structure and morphology, and described them as follows:

Fringing reefs lie near emergent land. They are fairly shallow, narrow and recently formed. They can be separated form the coast by a navigable channel (which is sometimes incorrectly termed a “lagoon”).

Barrier reefs are broader and lie farther away from the coast. They are separated from the coast by a stretch of water which can be up to several miles wide and several tens of metres deep. Sandy islands covered with a characteristic pattern of vegetation have sometimes formed on top of a barrier reef. The coastline of these islands is broken by passes, which have occupied the beds of former rivers.

Atolls are large, ring-shaped reefs lying off the coast, with a lagoon in their middle. The emergent part of the reef is often covered with accumulated sediments and the most characteristic vegetation growing on these reefs consists of coconut trees. Atolls develop near the sea surface on underwater islands or on islands that sink, or subside.


Fringing
Barrier
Atoll

Other reef types or variants

Apron reef – short reef resembling a fringing reef, but more sloped; extending out and downward from a point or peninsular shore. The initial stage of a fringing reef

Bank reef – isolated, flat-topped reef larger than a patch reef and usually on mid-shelf regions and linear or semi-circular in shape; a type of platform reef.

Patch reef – common, isolated, comparatively small reef outcrop, usually within a lagoon or embayment, often circular and surrounded by sand or seagrass. Can be considered as a type of platform reef[who?] or as features of fringing reefs, atolls and barrier reefs.The patches may be surrounded by a ring of reduced seagrass cover referred to as a grazing halo.

Ribbon reef – long, narrow, possibly winding reef, usually associated with an atoll lagoon. Also called a shelf-edge **reef or sill reef.**

Habili – reef specific to the Red Sea; does not reach near enough to the surface to cause visible surf; may be a hazard to ships (from the Arabic for "unborn")

Microatoll – community of species of corals; vertical growth limited by average tidal height; growth morphologies offer a low-resolution record of patterns of sea level change; fossilized remains can be dated using radioactive carbon dating and have been used to reconstruct Holocene sea levels[47

Ribbon reef – long, narrow, possibly winding reef, usually associated with an atoll lagoon. Also called a shelf-edge reef or sill reef.

Habili – reef specific to the Red Sea; does not reach near enough to the surface to cause visible surf; may be a hazard to ships (from the Arabic for "unborn")

Microatoll – community of species of corals; vertical growth limited by average tidal height; growth morphologies offer a low-resolution record of patterns of sea level change; fossilized remains can be dated using radioactive carbon dating and have been used to reconstruct Holocene sea levels.

Zones

Alternatively, Moyle and Cech distinguish six zones, though most reefs possess only some of the zones.
The reef surface is the shallowest part of the reef. It is subject to surge and tides. When waves pass over shallow areas, they shoal, as shown in the adjacent diagram. This means the water is often agitated. These are the precise condition under which corals flourish. The light is sufficient for photosynthesis by the symbiotic zooxanthellae, and agitated water brings plankton to feed the coral

The off-reef floor is the shallow sea floor surrounding a reef. This zone occurs next to reefs on continental shelves. Reefs around tropical islands and atolls drop abruptly to great depths, and do not have such a floor. Usually sandy, the floor often supports seagrass meadows which are important foraging areas for reef fish.

The reef drop-off is, for its first 50 m, habitat for reef fish who find shelter on the cliff face and plankton in the water nearby. The drop-off zone applies mainly to the reefs surrounding oceanic islands and atolls.

The reef face is the zone above the reef floor or the reef drop-off. This zone is often the reef's most diverse area. Coral and calcareous algae provide complex habitats and areas that offer protection, such as cracks and crevices. Invertebrates and epiphytic algae provide much of the food for other organisms.[48] A common feature on this forereef zone is spur and groove formations that serve to transport sediment downslope.

The reef flat is the sandy-bottomed flat, which can be behind the main reef, containing chunks of coral. This zone may border a lagoon and serve as a protective area, or it may lie between the reef and the shore, and in this case is a flat, rocky area. Fish tend to prefer it when it is present.

The reef lagoon is an entirely enclosed region, which creates an area less affected by wave action and often contains small reef patches.

How Do Reefs Form?

As the polyps live, reproduce, and die, they leave their skeletons behind. A coral reef is built up by layers of these skeletons covered by living polyps. The polyps reproduce either through fragmentation (when a piece breaks off and new polyps form) or sexual reproduction through spawning.

A reef ecosystem may be made up of many species of corals. Healthy reefs are typically colorful, highly biodiverse areas made up of a mishmash of corals and the species that inhabit them, such as fish, sea turtles, and invertebrates such as sponges, shrimp, lobsters, crabs, and seahorses. Soft corals, like sea fans, may be found within a coral reef ecosystem, but do not build reefs themselves.

The corals on a reef are further cemented together by organisms like coralline algae, and physical processes like waves washing sand into spaces in the reef.

Reefs as Ecosystems

When corals are babies floating in the plankton, they can be eaten by many animals. They are less tasty once they settle down and secrete a skeleton, but some fish, worms, snails and sea stars prey on adult corals. Crown-of-thorns sea stars are particularly voracious predators in many parts of the Pacific Ocean. Population explosions of these predators can result in a reef being covered with tens of thousands of these starfish, with most of the coral killed in less than a year.

Corals also have to worry about competitors. They use the same nematocysts that catch their food to sting other encroaching corals and keep them at bay. Seaweeds are a particularly dangerous competitor, as they typically grow much faster than corals and may contain nasty chemicals that injure the coral as well.

Corals do not have to only rely on themselves for their defenses because mutualisms (beneficial relationships) abound on coral reefs. The partnership between corals and their zooxanthellae is one of many examples of symbiosis, where different species live together and help each other. Some coral colonies have crabs and shrimps that live within their branches and defend their home against coral predators with their pincers. Parrotfish, in their quest to find seaweed, will often bite off chunks of coral and will later poop out the digested remains as sand. One kind of goby chews up a particularly nasty seaweed, and even benefits by becoming more poisonous itself.

Thank you