Rewarding Learning

eGUIDE//Biology

Biochemistry, Genetics and Evolutionary Trends

Unit A2 2 5.8 Kingdom Animalia

This e-book is designed to complement other support materials and enhance the understanding of this unit for students at GCE level. The topics covered are in accordance with those topics present in the current specification.

Contents

Kingdom Animalia

5.8

Learning Outcomes from A2 2 5.8

Students should be able to:

- Demonstrate knowledge and understanding of the body form of the Phylum Cnidaria (for example, hydra and jellyfish)
- Demonstrate knowledge and understanding of the body form of the Phylum Platyhelminthes (for example, planarium and liver fluke)
- Demonstrate knowledge and understanding of the key features of the body form of the Phylum Annelida (for example, earthworm and lugworm)
- Demonstrate knowledge and understanding of the body form of the Phylum Arthropoda (for example, insects and spiders)
- Demonstrate knowledge and understanding of the body form of the Phylum Chordate (for example, mammal and bird)

Kingdom Animalia

Body form of animals, sometimes called the body plan, can be used to identify a group of animals as belonging to a particular group or phylum. Each phylum possesses a 'unique organisation' of body structures.

A selection of phyla representing a progression in complexity in their body plans will be examined. All are multicellular organisms, which enables specialisation of cell and tissue structure and function, to a lesser or greater extent, when moving through the phyla.

The phyla are:

- Phylum Cnidaria
- Phylum Platyhelminthes
- Phylum Annelida
- Phylum Arthropoda
- Phylum Chordata

As progression through the phyla is made, the absence, presence, and degree of complexity of particular features of body organisation will be noted. These are:

Body symmetry

The organisms being examined exhibit one of two types of body symmetry;

- radial symmetry: body parts radiate outwards from a central point, like the spokes in a bicycle.
- bilateral symmetry: right and left sides of the body are mirror images of each other.

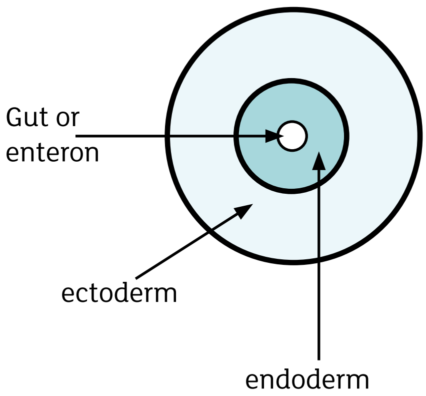
Differentiation of body layers

Body plans can be described in layers of tissue. The animal phyla being examined possess either two or three body layers around a central cavity or gut.

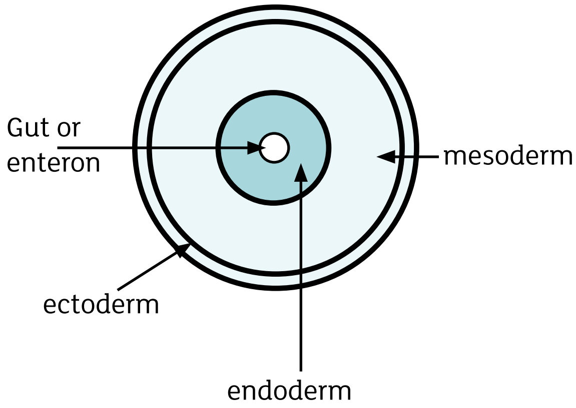
The layers are called;
- endoderm: the innermost layer
- mesoderm: the middle layer
- ectoderm: the outer layer.

Cnidaria, the least complex organisms, only possess two of these layers – the endoderm and the ectoderm, and are described as diploblasts.
All of the other phyla have all three body layers and are called triploblasts.

Diploblast



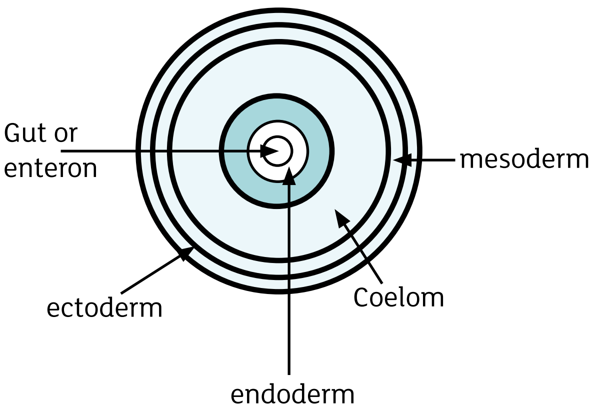
Triploblast



Body cavity or coelom (do not confuse with the gut)

The coelom is a fluid filled cavity in the mesoderm, lined by mesoderm on either side, as shown in the diagram below. It is found in most triploblastic animals.

Coelomate



The coelom separates the body wall and the gut, so that movements of the gut wall, for example, peristalsis does not affect the body wall, and movements of the body wall during locomotion, do not affect internal organs.

The coelom provides a space for specialised body organs and bathes internal organs in a fluid through which nutrients and waste products can diffuse.

The coelomic fluid can also serve as a hydrostatic skeleton.

Animals which lack a coelom are described as acoelomate.

Segmentation

Segmentation refers to bodies being composed of a number of repeating units. These become more specialised and complex as progression is made through the phyla.

Annelids are the first of the phyla to exhibit segmentation.

Cephalisation

As nervous systems increase in complexity, the concentration of sense organs and nerves near the anterior (front end) of the organism lead to the development of a definite “head” region.

Limb formation

As progress is made through the phyla, specialised external appendages such as legs and wings appear.

More information is available on the body cavity or coelom;
http://www.newworldencyclopedia.org/entry/Body_cavity
The CCEA Fact File on ‘Taxonomy and Classification’ has more information.

Phylum Cnidaria

Examples; jellyfish and hydra

The creatures in this phylum are radially symmetrical. This means that the parts of the body extend outward from the center like the spokes on a bicycle wheel.

Cnidarians have a soft sac-like body, which consists of two cell layers: an outer ectoderm and an inner endoderm. Therefore Cnidaria are diplobastic.

The endoderm lines the central cavity or enteron. Between these a jelly-like, largely non-cellular, layer called the mesoglea, is permeated by a complex network of supporting fibres.

There are two basic body forms;

- the free-swimming, bell shaped medusa (jellyfish)
- the sessile(attached to a surface) polyp (hydra).

In medusae, mesoglea comprises the bulk of the bell-shaped, motile organism.
The photograph below shows the crystal jelly, a bioluminescent jellyfish found off the west coast of North America.

© Frans Lanting / Mint Images / Science Photo Library

Crystal jelly, Aequorea victoria, Monterey Bay Aquarium, California.

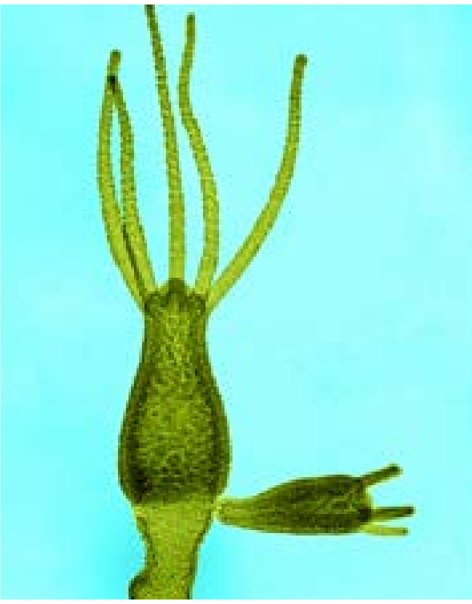
In polyps, the water-filled enteron acts as a hydrostatic skeleton, which, with the mesoglea, and the water in the environment, maintains its form.

The diagram and photograph below show hydra, a polyp form of Cnidaria. Note;

- the radial symmetry
- the body wall made up of two layers – diploblastic
- the single opening at the top of the organism into the enteron. This means that the 'mouth' of the enteron is used for both ingestion of food and egestion of unwanted waste products. There is no anus.
- hydra reproduce by a means of a type of asexual reproduction called budding.
- there is no waterproof covering or cuticle present.

Cnidaria have a primitive nerve net and can react to prey, but there is no complexity of organisation or cephalisation.

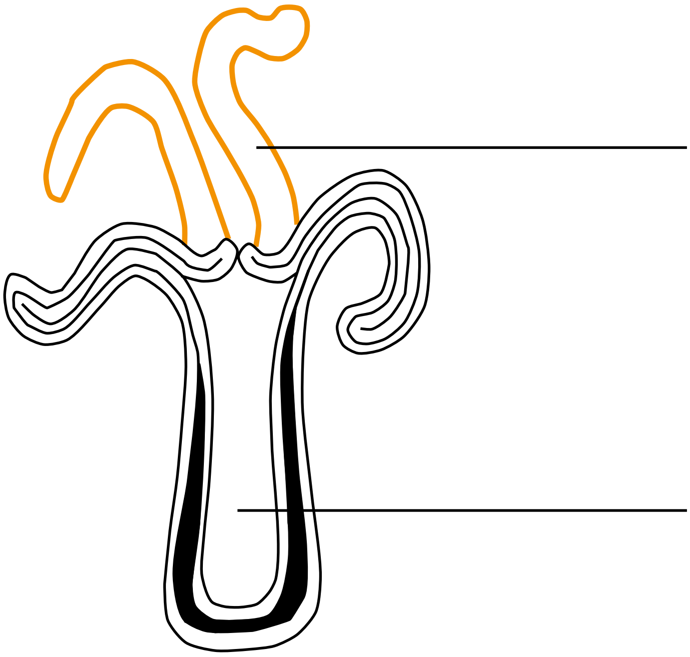
Diagram showing the body structure of a Hydra.



© Omikron / Science Photo Library

Colour enhanced light micrograph of a Hydra, with bud

Question:
Use the information above to label this diagram of a Hydra.
(Remember there is no mesoderm)



CNIDARIANS: SIMPLE ANIMALS WITH A STING! By the Oceanic Research Group looks at the radial symmetry of the polyp and medusae form of Cnidarians
http://www.oceanicresearch.org/education/wonders/cnidarian.html

Phylum Platyhelminthes

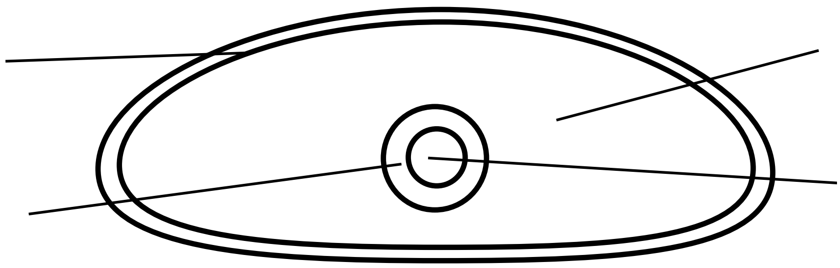
Examples; planarian and liver fluke

Platyheminthes are multicellular organisms, with some differentiation of tissues, often referred to as flatworms. The reason for this is that their worm-like bodies are flattened 'dorso-ventrally' (see the diagram and photographs below).

They exhibit bilateral symmetry.

They have three body layers, ectoderm, mesoderm and endoderm, and so are triploblastic organisms.

Use the information in the introduction to this section on body layers to label the diagram below.



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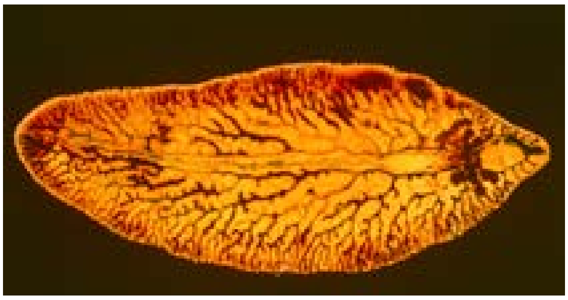


Light micrograph of an adult liver fluke, Fasciola hepatica, a parasite of sheep, cattle & humans.

© Michael Abbey / Science Photo Library

Flatworm. Coloured light micrograph of a planarian flatworm (class: Tubellaria). Its head is on the far left. This flatworm can grow to nearly 10 centimetres. It moves on a layer of mucus in the manner of slugs, and is nocturnal to avoid the drying heat of the day.

From the photographs and diagram above there is:

- No segmentation and
- They do not possess a body cavity or coelom i.e. they are acoelomate.

Platyhelminthes have a nerve system and display cephalization having a simple 'brain'.

© Dr Keith Wheeler / Science Photo Library

Freshwater flatworm. Macrophotograph of a Dugesia lugubris flatworm. This non-parasitic flat worm is covered in cilia, which enables it to glide in water, such as in a pond, and also in moist leaf litter, as on this beech leaf. When disturbed it twists its body to set off in a new direction. The eye spots (ocelli, upper centre) help locate prey. This flatworm is carnivorous, feeding on small crustaceans and insect larvae. The mouth is on the underside of the body, and leads to the gastrovascular cavity where digestion takes place. Excretion is through pores in the body surface, and respiration also takes place through the external surface.

They have a simple opening to the gut and digestion is completed in the enteron. They have no anus, and therefore an incomplete digestive system.

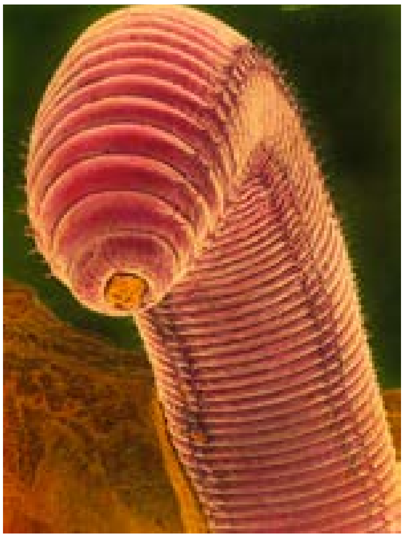
Platyheminthes have no skeletal structure, circulatory or respiratory systems. Their flattened shape increases surface area and compensates for the lack of respiratory and circulatory systems.

Phylum Annelida

Examples; earthworm and lugworm

Annelids are triploblastic (3 body layers), multicellular animals with some tissue differentiation.

They are bilaterally symmetrical and round in transverse section.



© Steve Gschmeissner / Science Photo Library

Common earthworm. Coloured scanning electron micrograph (SEM) of the rear end of a common earthworm (Lumbricus terrestris). The anus (light brown) is found on the earthworm's last segment (pygidium). Also visible are the chaetae, tiny thorn-like projections which are used for movement.

They are the first group in the progression to possess;

- A coelom; fluid filled body cavity in the mesoderm.
- Segmentation: metameric segmentation, in which each segment has its own muscle, blood vessels and nerve supplies. The nervous system consists of paired nerves and ganglia arranged along the segments of its body.
- Some segments have reproductive organs.
- A complete digestive system with a mouth and an anus.
- A cuticle (non-chitinous) for protection.

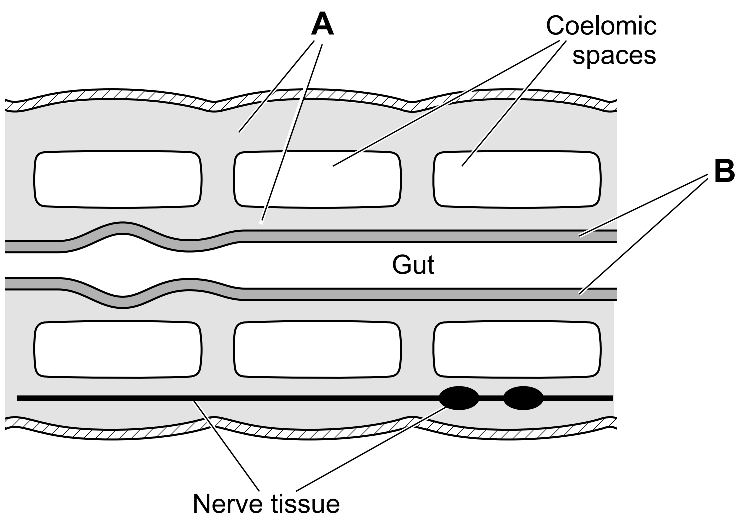
Gas exchange takes place along the length of its body.

© Dr Keith Wheeler / Science Photo Library

Light micrograph of a transverse section through the body of a round segmented earthworm (Lumbricus terrestris) in the intestinal region. The intestine is circular, (centre). In the body cavity (white) are the excretory organs, the nephridia (kidney-like organs, pink, right and left), and the nerve cord (pink, lower centre). The outer ring (pink) consists of the epidermis, circular muscles, and longitudinal muscle (radiating lines). The gaps in the outer ring are bristles (chaetae) that help the movement of earthworms in their burrows.

The photograph above shows the ectoderm, mesoderm, coelom, endoderm and enteron. It also shows gaps where chaetae (bristles) are arranged which facilitate movement.

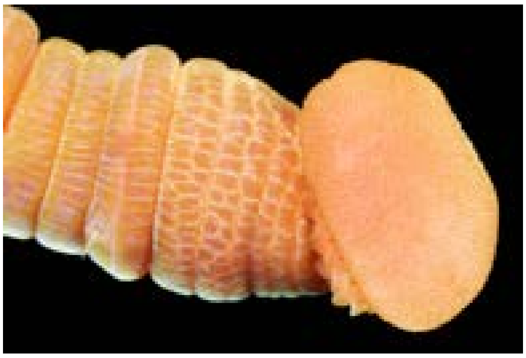
The diagram below represents a section through an annelid such as an earthworm. Complete the diagram by identifying the body layers A and B.



Note from the above diagram that the coelom also appears segmented. These segmented fluid-filled body cavities provide a hydrostatic skeleton, supporting the annelid's body through the pressure exerted by the fluid against the body wall.

Annelids have a closed tubular circulatory system.

© Alexander Semenov / Science Photo Library



Close-up of the head of a lugworm (Arenicola marina). Lugworms are a marine species of annelid worm that have parapodia (hair-like outgrowths) and gills. They live in tubes in the seabed where they filter the sand for oxygen and food.

Phylum Arthropoda

Examples; insects and spiders

Arthropods are multicellular, triploblastic animals with differentiated tissues. They are also bilaterally symmetrical.

Arthropods have a fixed number of metameric segments. The metameric segments exhibit a greater degree of specialisation than annelids.

Look at the photographs of the winged ant (insect) and house spider below. Note the difference in the number of body segments and legs.

© Henrik_L_iStock_ThinkstockPhotos

Note the distinctive 'three body segments'

- ***head, thorax and abdomen.***

*Insects also have **3 pairs of jointed legs and two pairs of wings***

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The House spider (Tegenaria domestica) regularly appears in homes and sheds across the UK; an adaptation from living inside caves and tree hollows.

Note: the two body segment arrangement

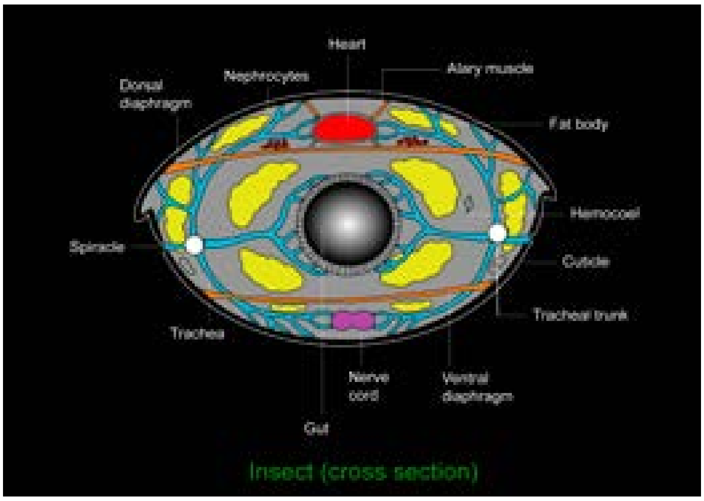
- ***head (fused head and thorax) and abdomen***

*Spiders have **4 pairs of jointed legs.***

Looking at the computer generated diagram of a cross section through an insect below, you can see the increased degree of complexity and specialisation in comparison to annelids.

For example – a heart pumps a fluid called haemolymph, similar to vertebrate blood, around the body, in close contact with the body tissues. In fact the haemolymph circulates in the coelom, which is reduced to form the haemocoel.

There are a variety of gas exchange systems – insects have openings on their surface called spiracles.



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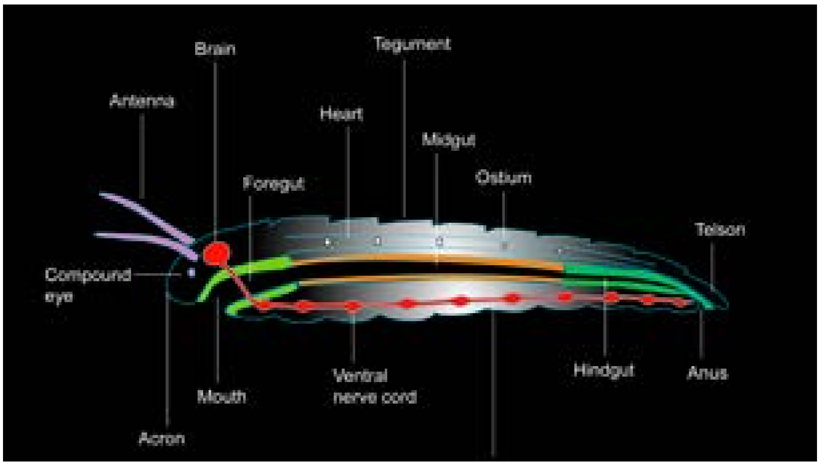
Computer artwork of a cross-section through the body of a typical insect showing the main structures and organs.



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Computer artwork showing the main structures and organs of a typical arthropod (legs not shown).

The diagram above shows:

- metameric segmentation
- the haemocoel (reduced coelom)
- a complete digestive system with mouth and anus, and specialisation of regions between into foregut, midgut and hindgut
- cephalisation – the presence of a brain
- a ventral nerve cord.

Arthropods have a hard jointed exoskeleton (made of chitin) to enclose and protect muscles and organs. As such, growth requires a moulting stage (ecdysis).

It is important to understand that the basic body plan of arthropods has facilitated rapid evolutionary development in many directions including flight, to make arthropods, particularly insects, the most successful animal group in terms of;

- the number of species
- overall number of individuals.

Phylum Chordata

Examples; mammals and birds.

Chordates are multicellular triploblastic organisms with highly differentiated tissues.

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Costa's Hummingbird (Calypte costae) male at monkeyflower.

They exhibit the following characteristics:

- bilateral symmetry
- well-developed coelom
- segmented body (head, thorax and abdomen in humans)
- cephalisation – a single, dorsal (back *of* body) tubular nerve cord and the anterior end (head end) is usually enlarged to form a brain
- complex nervous system
- segmented muscles in an un-segmented trunk
- ventral (front *of* body) heart, dorsal and ventral blood vessels within a closed circulatory system
- completed digestive system – mouth and anus with a high degree of specialism of regions in-between
- bone or cartilaginous endoskeleton to provide body support and protection for body organs
- jointed limbs/bones.

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Southern Elephant Seal face (Mirounga leonina), South Georgia Islands, Antarctic region.

Read this article entitled ‘Segmentation is the secret behind the extraordinary diversification of animals’
http://www.sciencedaily.com/releases/2010/07/100726222316.htm

Questions

1. a) The planarium has a flattened body shape. Explain the advantage of this body shape to the planarium.

   b) Earthworms belong to the phylum Annelida. Annelids possess a coelom and are described as coelomate. Describe precisely the term coelomate.

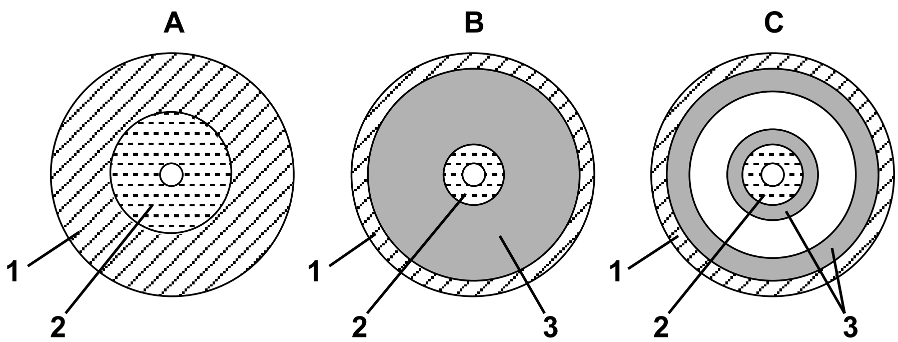
   c) Suggest one advantage for the possession of a coelom.

   d) Earthworms are detritivores and they feed by ingesting leaves and other organic material into their gut. Digestion in earthworms is extracellular.
   With reference to the earthworm, describe what is meant by extracellular digestion.

   e) The digestive system of annelids may be regarded as being more highly adapted (evolved) than in platyhelminthes. Describe one way in which they are more highly adapted and explain the advantage of this adaptation.

   f) Describe three features found in members of the phylum Annelida, which are not found in *Hydra*.

2. The diagram below represents transverse sections through three different animal phyla A, B and C.



   a) Identify the body layers 1, 2 and 3.

   b) Identify which of the transverse sections (A, B or C) represents a member of the phylum Platyhelminthes.
   Give one reason for your answer.

   c) Which section (A, B or C) represents a phylum that shows radial symmetry?

   d) Which section (A, B or C) represents a phylum in which chaetae would be present?

3. In the Animal Kingdom, the phyla show increasing complexity in the sequence Cnidaria, Platyhelminthes, Annelida and Chordata. Describe and explain how evolutionary progression is evident in this sequence.

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