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PSG PROGRAMME (NCQF LEVEL 5).

MODULE 10

AMPHIBIANS – (Frogs and Toads).

OBJECTIVES (10.1).

- On completion of this module you will:
  - Know the characteristics of the class of amphibians.
  - Be able to explain the differences between frogs and toads.
  - Understand the life cycle of frogs and toads and be able to briefly explain metamorphosis.
  - Be able to explain mating postures, nests, types of frog eggs and frogs.
  - Be able to name and explain the different types of frog calls.

INTRODUCTION TO AMPHIBIANS (10.1.1)

- Biologists maintain that life on earth was confined to the water for many million years before it became possible to colonize terrestrial habitats. At the end of the Devonian period (age of fishes) it is thought that changes occurred which resulted in the evolutionary development of life on land. The development of lungs and leg-like fins in some of the earliest bony fishes was probably an adaptation for survival. Great climatic changes took place during the Devonian; ponds and streams dried up or became stagnant. Typical fish could not have survived these conditions. The development of lungs was therefore essential to escape the degrading habitat in which they found themselves. It is believed that these 'lung fish' were transitional forms between the fish and the amphibian, and the amphibian are one of the earliest known group of vertebrates on earth with fossil remains dating back to 400 years ago.
- Within the class of amphibians, the three orders viz. **Adopa, Caudata and Anura.** Only members of the Anura are found in Southern Africa.
  a) The Order **Caudata** – consists of newts and salamanders. These amphibians have a tail throughout their life and are only found in Europe, Asia and Americas.
  b) The Order **Adopa** – consists of caecilians which are worm-like amphibians which have no legs.
  c) The Oder **Anura** (meaning no tail) – it is sometimes also called **batrachian**. These are frogs and toads with which we are all familiar with.
- The word **amphibian**, comes from the Greek word "**amphi**" (of two kinds) and "**bios**" (life), referring to the two stage life cycle in frogs:
  a) An aquatic immature (tadpole) with gills, fins and tail.
  b) The terrestrial four-legged adult with lungs.

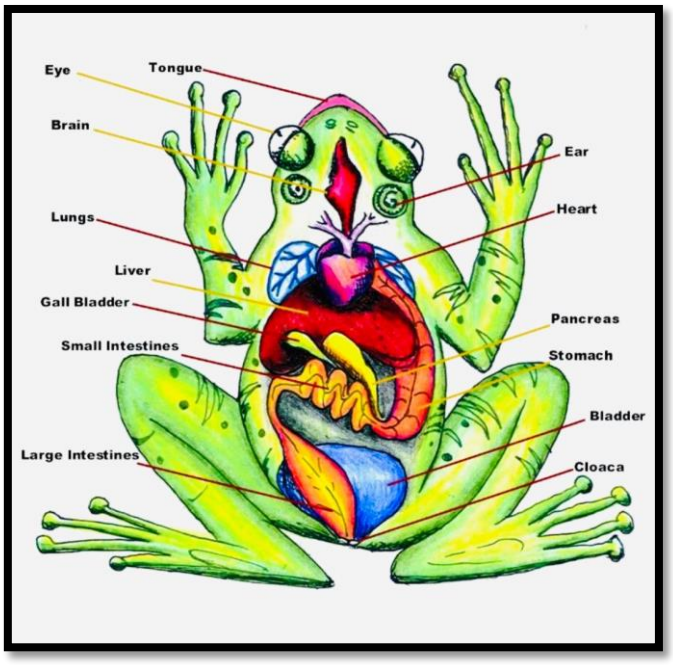
- Amphibians are the only living vertebrates that have a transition from water to land in both their evolutionary and their individual development. After some 350 million years of evolution, very few amphibians move between water and land environments. The frogs and toads are the largest group of modern amphibians. There are more than 7,700 species of frogs and toads worldwide, with 169 species occurring in Southern Africa of which 135 occur in South Africa. The number of recorded species changes as research is carried out on an ongoing basis.
- Amphibians are **ectothermic**, primitively quadrupedal (four-footed, using all four feet for walking and running) vertebrates that have glandular skin and breath by means of lungs, gills or skin. Most of the amphibians have **biphasic** life cycle that begins with an aquatic larva, which later goes through metamorphosis to reproduce a land living adult that returns to water to lay eggs. Breathing occurs through the porous skin in all amphibians and is supplemented in most amphibians by lungs.
- The only amphibian representative in Southern Africa is the Order Anura to which frogs and toads belong. The name the Oder "Anura" refers to the absence of tails in adults.

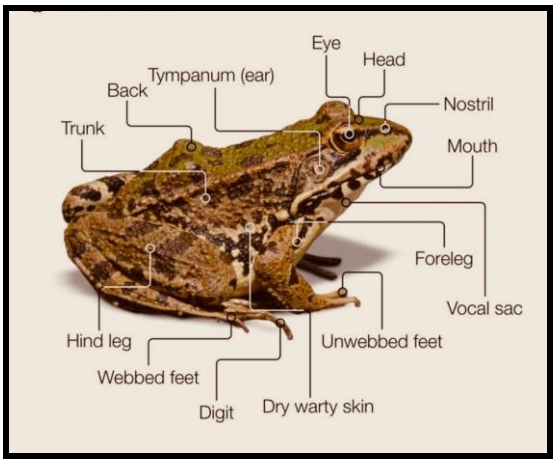
❖ Some of the features that characterize amphibian of the Order Anura are:

- The skin is smooth, soft and moist with many glands.
- Respiration (breathing) is either by lungs, skin, mouth lining, the pharynx or a combination of these.
- None have tails in the adult form.
- They have ten pair of **cranial nerves** (transmits information from brain to various parts of head & neck).
- Fertilization is external, and all species undergo metamorphosis lifestyle.
- All have four well-developed jumping limbs; the feet of which are mostly webbed or partially webbed.
- Very few have claws at the ends of the digits.
- Circulation is by means of a three-chambered heart.

BASIC FROG ANATOMY/PARTS (10.1.2)

- The skin of frogs and toads are soft, lack scales and are usually quite glandular. In many species these glands are able to secrete toxic substances as a defense mechanism. The nostrils are situated on top of the snout to minimize that part of the body visible above the surface of the water and have valves which prevent the ingress of water. The ear is a simple tympanic membrane or eardrum.
- The rear legs are highly modified for a jumping way-of-life, and possess an extra joint to aid in this. The hind feet bear five toes which is used to capture prey. The tongue is articulated at the front of the mouth and not at the rear as in other animals and the eyes are protected by two eyelids, one upper and lower. (See frog anatomy picture below):





❖ The difference between frogs and toads:

Characteristic.	**Frogs.**	**Toads.**
Skin	Moist and smooth	Drier skin. Has small glandular bumps that are often called warts.
Teeth	Some frogs have teeth on the upper jaw.	Do not have teeth.
Habitat	Often in water	Spend most of their life on land and are able to live in drier areas.
Egg-laying	Lay eggs in clumps	Lay eggs in strings
Body shape	Generally more slender, long legs adapted for swimming and jumping.	Stout and compact bodies, Shorter legs than frogs.
Activity	May also be active during the day.	

❖ Of 54 frog families found around the world (except Antarctica), occur in Southern Africa; comprising about 169 species and divided into 34 different genera. About 31 species in 7 families have been recorded in Botswana.

❖ Southern African families, with reference to local occurrence (Northern Botswana) are detailed below:

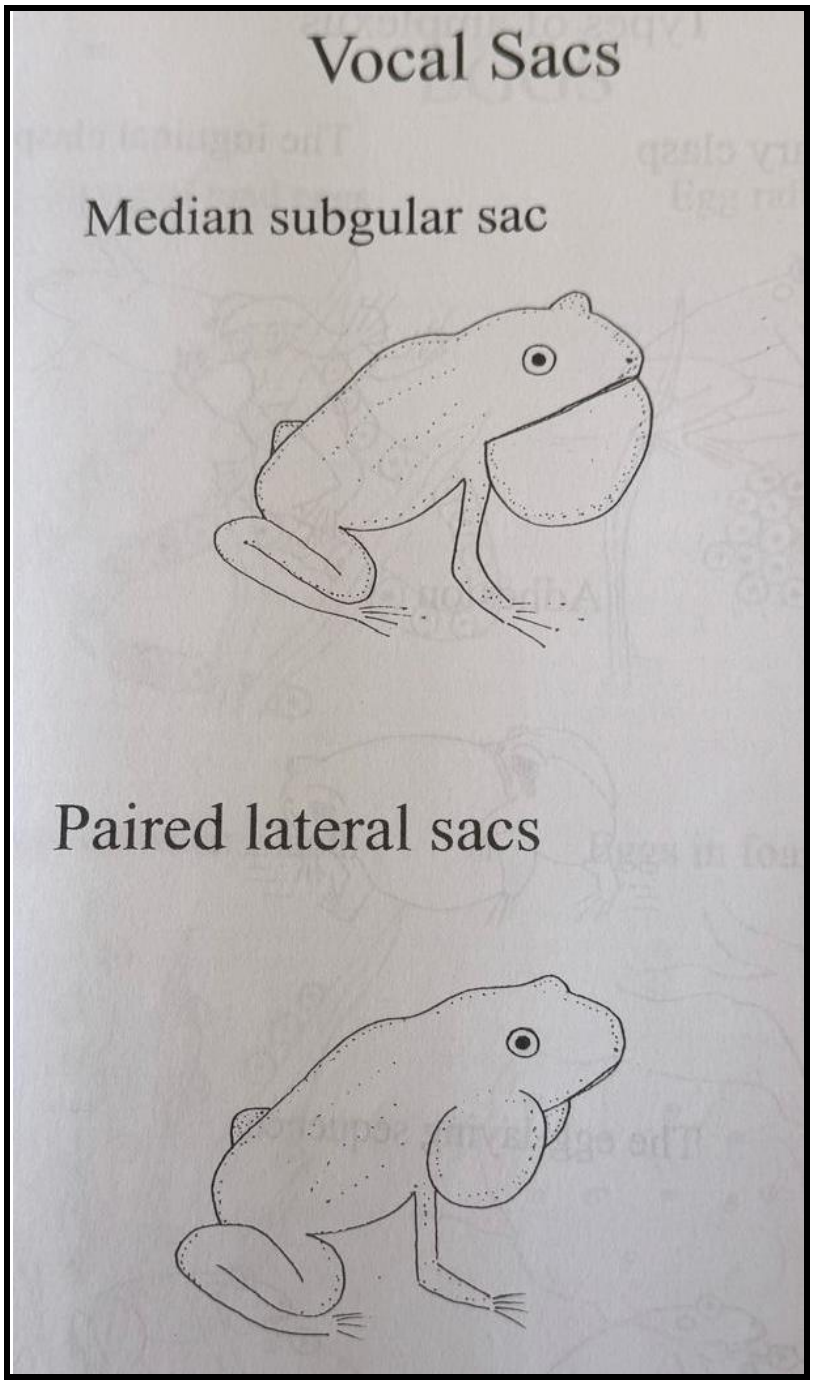
- Family - Arthroleptidae ** **None found locally** **
  - Squeakers.
- Family - Bufonidae.
  - Toads:
    - Guttural toad
    - Flat-backed toad

        - Western olive toad
        - Northern pygmy toad
        - Kavanga pygmy toad
        - Red toad
        - Lemaire`s toad
    - Family - Heleophrynidae **__None are found locally__**
        - Ghost Frogs.
    - Family - Hemisotidae
        - Shovel-nosed Frogs
            - Mottled shovel-nosed frog
- Family - Hyperoliidae.
    - Sub-family - Kassininae.
        - Kassinas and leaf-folding frogs = Bubbling kassina.
    - Sub-family - Hyperoliinae
        - Reed Frogs = Long reed frogs and Painted reed frogs.
    - Sub-family - Leptopelinae
        - Tree Frogs = Bocage`s tree frog
- Family - Microhylidae.
    - Sub-family - Breviceptinae
        - Bushveld rain frog.
    - Rubber Frogs
        - Banded rubber frog
        - Spotted rubber frog
- Family - Pipidae
    - Platannas = Tropical platanna
- Family - Ranidae
    - Sub-family - Raninae = Sand, river, stream & grass frogs, and bullfrogs.
        - Tremelo sand frog
        - Knocking sand frog
        - Russet-backed sand frog
        - Common river frog
        - Plain grass frog
        - Speckled-bellied grass frog
        - Mascarene grass frog
        - Broad-banded grass frog
        - Dwarf grass frog
        - Ornate frog
        - Giant bullfrog
    - Sub-family - Petropedetidae = Chirping, puddle, cacos and marsh frogs.
        - Common caco
        - Snoring puddle frog
        - Dwarf puddle frog
- Family - Rhacophoridae

    - Foam-nest frog
        - Foam-nest frog or grey tree frog.

FROG CALLS (10.1.3).

- All frogs are vocal to some extent. Frogs are heard calling more than they are seen. Most frog species are capable of making a variety of sounds. The various sounds made will convey specific information that is important to the day-to-day living of the frog. Frogs are able to recognize each other by means of very specific sounds that only that particular species will make. This makes it easy to recognize the calls of the different species. Most frogs only call regularly in summer where warmer temperatures and rain are the main factors start them calling. There are two types of vocal sacs found in Southern African frogs, the **median sub-gular sac** the **paired lateral sacs**. (see diagrams below):



- To produce the sound, air is passed over the vocal chords and is then resonated in expanded pouches of skin called vocal sacs under the throat. There can be one or two sacs and the single breath is passed back and forth between the lungs and the vocal sac/s for maximum efficiency. Platannas are different in that they call underwater and don`t use vocal sacs but instead 'buzz' by vibrating cartilage in the voice box.
- When calling, the different species will utilize different times so as not to cause confusion. In this way some species will start around sunset and after a while they stop to be followed by one or two other species. It goes like this in 'shifts' until all have had a chance to find mates - a process called **timeshare calling.**
- **Time-share calling** - At a dense breeding chorus at night, males next to each other call alternatively producing a regular advert. These males are effectively sharing time avoiding call overlap. Other species achieve the same effect by the call of the first male triggering other nearby males, so that each delivers his call, in sequence. This time-sharing by males may serve a few functions:
  1. Allow one male to space out from another by listening to the loudness of his neighbor`s voice heard during the intervals between his own calls.
  2. It may also provide a clearer guide to females regarding the exact location of each male.

❖ There are different types of calls that frogs make:

1. **Advertisement calls** - these are only produced in the breeding season. Many male frogs get together at what is called a breeding site, and all call together in a concert. These calls are made to advertise to the females that they are here and to attract the females to them in order to mate.

2. **Aggressive calls** - The uttering of aggressive calls by interacting males often results in one or both individuals either retreating or becoming silent. These calls are more common in dense choruses than in smaller groups. If the spacing pattern between males that are next to each other breaks down, that is, if the males get too close to each other physical combat may start up and aggressive calls are uttered frequently until one male is displaced by the other.

3. **Release calls** - In most species of frogs, the males clasp both females and other males purely for the fact that they will try and mate with any other frog. If the individual seized is another male or a female who is not ready to mate, it expels air from the lungs in short bursts causing a vibration of its sides. These calls differ from advertisement and cause the frog to release the clasped frog. Release calls thus convey information to the amplexing male that an inappropriate sexual partner has been clasped and amplexus is quickly terminated (ended).

4. **Distress calls** - Distress calls emitted with the mouth open are scream-like and produced when a frog of either sex is seized by a predator. These calls may aid escape by startling a mammalian or avian predator. Distress calls may also alert other individuals to the presence of danger.

❖ **Frog Satellite behavior.**

- A close observation of the breeding site of a variety of species of frogs often reveals the presence of a small number of sexually mature, but silent males, each one being in close proximity to another actively calling male. The silent individual is tolerated by the calling frog because the call intensity spacing mechanism in this instance is not operational, as no call is being produced. The silent males then intercept females that are attracted to their calling neighbor. Individuals often change to satellite behavior when strong calling males are in close proximity.

❖ **Reproduction.**

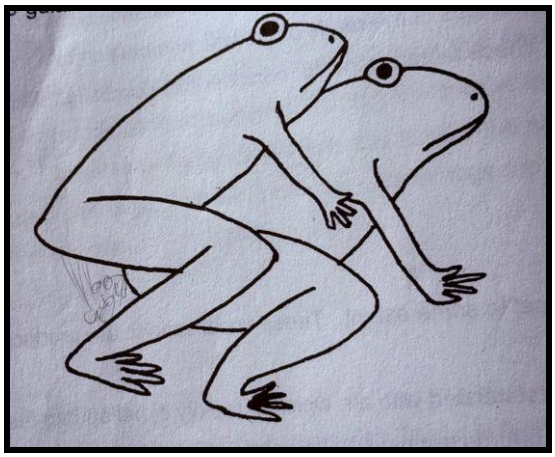
- A sexually receptive female will home in on the call being delivered by a male of the same species. Once in close proximity, the male clasps the female in readiness for mating. This clasp is known as **amplexus** (when the male clasps (holds) the female to mate with her.
- Frogs display external fertilization which means that the eggs and sperm meet outside of the body. The smaller male usually holds onto the back of the female and deposits sperm onto the shell-less eggs as they are laid. Tadpoles emerge from the eggs and they are characterized as follows:

    - Vegetarian with specialized sucking mouthparts.
    - Have tail and fins.
    - Obtain oxygen from water by means of gills.
    - Have no eyelids or tongue.
    - They then undergo what is called **metamorphosis** - a transition from one life cycle stage to another. This is a gradual process and happens while they actively move around; they do not go into a cocoon like insects do.

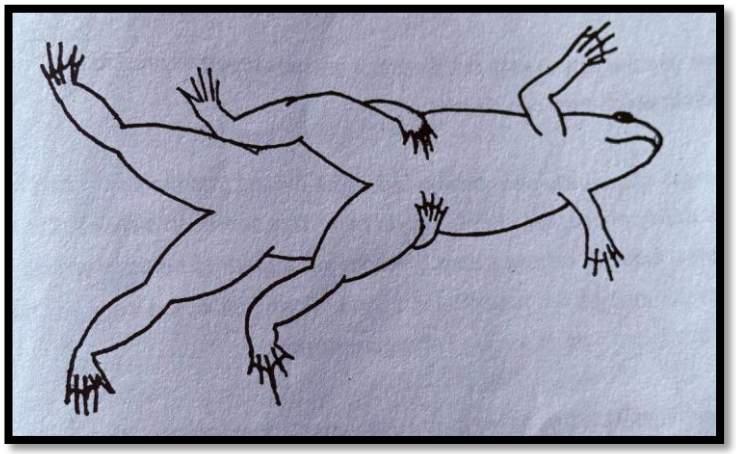
❖ **Mating Behavior (amplexus).**

- There are three types of amplexus, depending on the species:

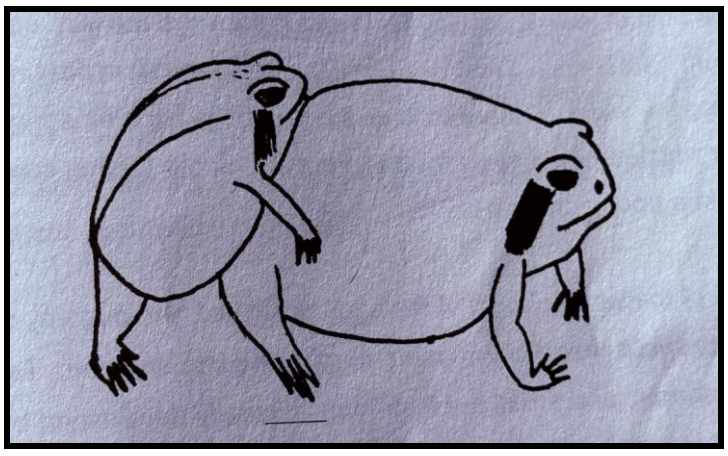
1. **The axillary clasp** - the male grasps the female tightly with his forelimbs just behind the forelimbs of the female. The male straddles the females back. During amplexus the males grip is maintained by special pads (nuptial pads) on the thumbs or arms of the male. (See diagram below):



2. **The inguinal clasp** - this occurs in the more primitive highly aquatic families that mate in the water (Platannas - *Xenopus laevis*). The male clasps the female around the waist just in front of her hind limbs. The eggs pass over the underside of the male and over his cloaca (mating organ). (See diagram below):



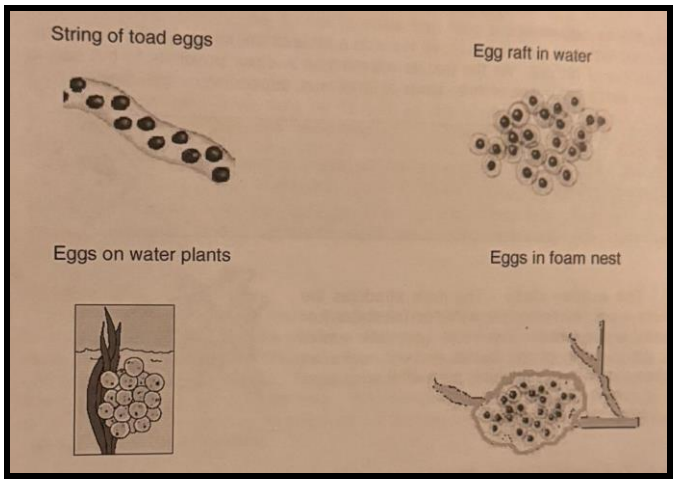
3. **Adhesion** - this is exhibited by the rain frogs where the male becomes glued to the female for the duration of the fertilization process. The positioning of the male on top of the female, appears to indicate that fertilization is internal, but this is not the case. Fertilization in frogs is external, the male simply deposits sperm over the eggs as the female lays them. At the moment when eggs are released from the female, the male sometimes lifts his feet up towards the cloaca of the female and ejaculates his sperm into the funnel created by his feet. The sperm then flows down between his feet and over the eggs, thereby ensuring fertilization. The process is known as **spawning.** (See diagram below):



❖ **Eggs.**

- Frog eggs are usually small (about 1 - 2 mm in diameter) and spherical. Most are covered with a jell-like substance that does not form part of the egg itself. This jelly is deposited on the eggs as they pass down the oviducts of the female prior to being laid. The way in which this jelly is deposited on the eggs determines the overall

appearance of the eggs when they are laid. Eggs may be deposited singly, in rafts, strings etc., depending on the species. (See pictures of amphibian eggs below):



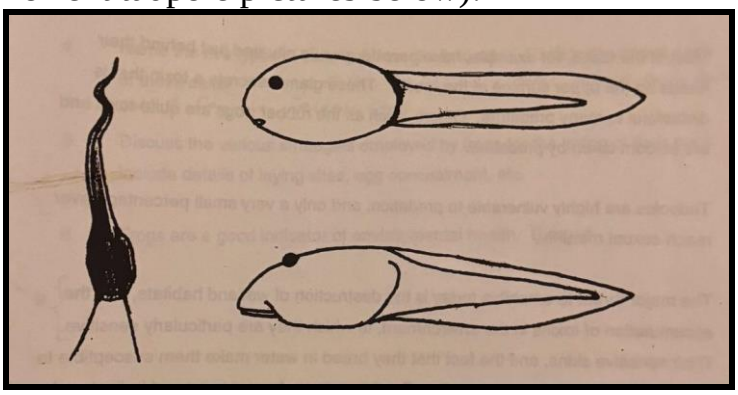
❖ Toads lay eggs that attached in strings (always in water) while all other frogs lay individual eggs in a solid mass (not always in water).

❖ Interestingly, the small, fat male rain frog cannot hold onto the female in the normal way when mating, so the female secretes a "glue" from her back that actually sticks the male to her. Only after the eggs have been laid does she secrete the solvent that dissolves the glue allowing the male to get loose.

- The jelly has multiple functions, one being to stick the eggs to underwater plants so that they don`t drift away in currents. The sticky surface also allows particles of silt and dirt to adhere to the egg, thus camouflaging it. The jelly also has an antibiotic compound present in it which serves to protect against the ingress of bacteria etc. Some frog species use jelly to stick the blades of grasses together around the eggs to form a pouch in which they can develop.
- Frog eggs are usually **counter-shaded** which means that the upper half of the egg is more darkly pigmented than the lower half. This serves to disguise the egg from predators. Looked from above, the eggs will appear to blend in with the color of the mud on the bottom of the pond. From below, the eggs will fade out against the bright light of the sky.
- The locations in which frogs lay their eggs varies considerably. The majority of our species deposit their eggs in open water without the benefit of a nest. Other species construct a nest of leaves underwater in which the eggs are laid, e.g., Leaf-folding frogs. Female shovel-nosed frogs will however stay close to the eggs and when the tadpoles hatch, she will dig a tunnel to the water and allow tadpoles on to her back and then take them down the tunnel. Foam-nest frogs lay their eggs in a foamy nest built in the branches of a tree overhanging the water. Others such as the rain frogs lay their eggs underground in a chamber which they excavate for this purpose. Some foreign species even carry their eggs in a pouch on their back.

❖ **Tadpoles.**

- Regardless of the whereabouts of the eggs being laid, the majority of frogs undergo a **larval or tadpole stage** before metamorphosing into adult. Tadpoles come in a variety of shapes and sizes, but their form is usually determined by the environment in which that species chooses to live.
  a) **Nektonic tadpoles** - live in open water and feed on plankton. They seldom rest on the bottom, but remain suspended by rapid movement of the tail which allows them to "hover" in one place. Platanna tadpoles belong in this group.
  b) **Benthonic tadpoles** - are bottom dwellers and feed mostly on plant matter. These are the normal tadpoles that most of us are familiar with. The majority of Southern African species have tadpoles of this form.
  c) **Torrent tadpoles** - are usually quite flat in appearance and have a sucker-like mouth on the ventral surface of the head. This is used to anchor the tadpole onto the substrate of streams in which they live. They are normally quite powerful swimmers. Ghost frogs have tadpoles of this kind. (See Nektonic, Benthonic and Torrent tadpole pictures below):

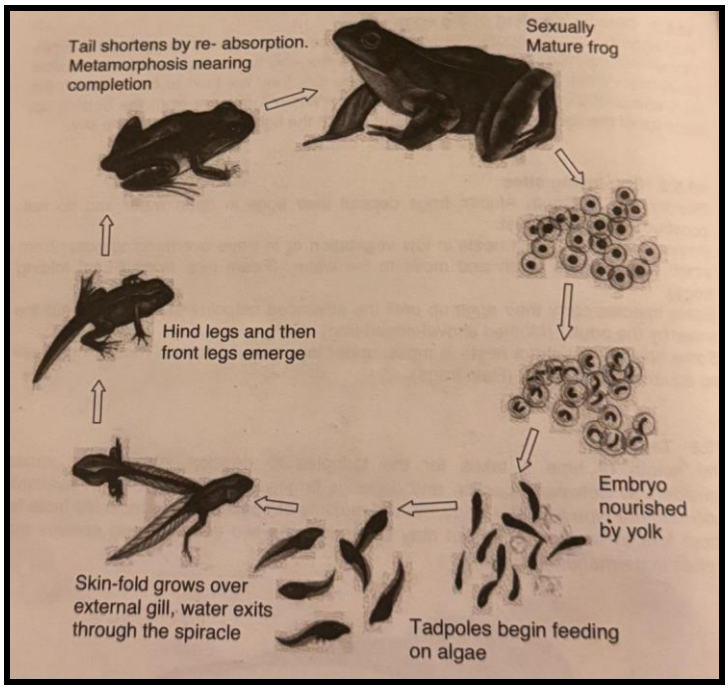


- Terrestrial tadpoles do not enter into a true tadpole stage, but emerge from their underground nests as metamorphosed froglets. The eggs laid by these species are usually very large and are well supplied with nutrients. This allows the young to develop very rapidly into froglets without the need to feed whilst doing so. The rain frogs exhibit this type of larval stage.
- The length of time it takes the tadpole to develop into a froglet can vary considerably, even within the same species. The development is dependent on factors such as temperature of the water and food supply. Some species may take as long as two years to metamorphose. Species that are adapted to arid environments tend to have shorter larval stages as an adaptation to scarce water resources. The majority of tadpoles take between 4 and 12 weeks to develop. Tadpoles are highly vulnerable to predation, and only a very small percentage ever reach sexual maturity.

METAMORPHOSIS (10.1.4)

- The metamorphosis of tadpoles into froglets takes place over a relatively short period of time and requires many changes to the overall structure of the larva. These changes are hormonally controlled. Structures that were once useful to the tadpole

now become redundant. These include the tail and its fin folds, gills and its larval mouthparts. At the same time, new structures needed by the adult frog develop. These include the lungs, limbs, eardrums, tongue, eyelids and a cornified skin. At this time there is the transition to air breathing from gill breathing. The herbivorous diet alters to an insectivorous diet. The speed of the changes that take place in metamorphosis is important because while they are taking place, the little froglets are vulnerable and not well-adapted to life on land or in water and may easily be eaten by predators. (See metamorphosis in frogs below):



- The result is a four -legged adult with the following characteristics:
  - Carnivorous with chewing mouthparts.
  - No tail and fins, replaced with legs.
  - Obtain oxygen from the air by means of lungs.
  - Has eyelids and tongue.
  - Have different type of skin.

SKIN (10.1.5).

- The skin of frogs differs from that of other vertebrates by being **permeable** to water (water can easily pass in and out through the skin). It is therefore easy for frogs to **dessicate** (dry out) if not protected in dry conditions. Air also moves freely through the skin allowing frogs the advantage of also being able to breathe (absorb oxygen) through this organ directly into the bloodstream. Air is pumped in and out of the lungs by the continuous fluttering of the throat.
- The skin has a variety of glands that help to keep the skin moist (some frogs can change color slightly to become lighter and reflect sunlight in dry areas); many species of frogs are able to change color quite rapidly to suit their surrounding environment. When pigment is dispersed throughout the cell, the skin color darkens

and when pigment is condensed within the cells into compact masses, the skin color lightens, and many have poisonous secretions that are used in defense.

- **Cryptic coloration** - concealment through body color is important both when the frog is trying to avoid predators and when acting as a predator itself. To blend with the environment the frog matches the skin color of the background or matches the color pattern with the environment. These colors are the result of **pigmentation** found in the skin of the frog. These changes take place through **hormonal control** in the pigment bearing cells - the **chromatophores.**
- **Thermoregulatory coloration** - is important to species of frogs that are frequently exposed to bright sunlight conditions. The darker the frog, the greater the amount of heat that is absorbed. Conversely, the lighter the frog, the greater the amount of light that will be reflected. By regulating these colors, certain frogs are able to gain some thermoregulatory benefit.

❖ **Diet and Feeding**.

- All frogs are carnivorous. The vast majority feed on arthropods and other invertebrates, but some such as the bullfrogs are able to take prey such as rats, snakes and other frogs etc. They take live prey that is swallowed whole. The platannas spend their entire time in the water and ambush, pursue and grab prey directly with mouth. Most frogs, however have a long sticky tongue that is flicked out (like that of a chameleon) to grab hold of prey and pull it back into the mouth.
- Frogs have no teeth but some have tooth-like projections in the roof of the mouth that are used as an aid in swallowing and grasping prey. If the prey is very large, the eyeballs can be pressed down into special cavities in the throat to aid in swallowing. Bullfrogs have serrations in the upper jaw with 2 sharp, hard projections in the lower jaw for holding onto their larger prey.
- One would think that competition for prey would be fierce between frogs. This is not the case however; competition is reduced by factors such as size and preferred foraging areas. A large frog will consume large items of prey rather than expending energy on eating very small prey. This reduces competition between them and small frog species. Foraging areas also differ substantially. A frog feeding on mosquitoes at the tops of reeds offers little competition to a frog feeding at the waters edge. These factors allow for considerable population densities of frogs in a small area.

❖ **Habits.**

- Most frogs tend to be active at night and spend the day resting up to avoid detection. Reed frogs will hide in the vegetation, flattening themselves to become inconspicuous, while sand frogs and shovel-nosed frogs will burrow into the soil and hide underground. The sand frogs have special tubercles on their heels to aid in digging, which they do by corkscrewing backwards into the soil. The shovel-nosed frogs have a specially pointed snout with which to dig headfirst and have small eyes adapted to this behavior. Bubbling kassinas will stay in burrows made by other animals. Banded-rubber frogs will hide in hollow logs.

- At night as the calling starts, many of these species will call from their burrows to amplify the sound and will then make their way down to the water, some of them walking or running and not hopping. Females are usually the larger sex, but the males are bigger in the bullfrogs.

❖ **Defense and Enemies.**

- Frogs are heavily preyed on by all manner of predators. Their most common form of defense is to escape by leaping. Some species have prodigious (remarkably) leaping powers and are capable of covering several meters in just a few quick jumps. This method of escape is quite successful for many species, but others are not adapted to leaping and therefore rely on other escape strategies.
- Toads secrete a whitish fluid from large **parotid glands** on the neck. These contain cardiotoxins and can cause heart failure in humans. Platannas have a slippery mucous on the skin (as they are permanently in water), that taste bad, makes them difficult to hold on to and it is also toxic; which is why hamerkops, herons and storks beat them so vigorously before eating them. Platannas will also use the sharp claws on their hind feet to rake enemies. The banded rubber frog is another species with a powerful toxin - they advertise the fact with their bright red and black coloration (aposematic coloration), while painted reed frogs probably use the bright flash of red on the inside of the legs to frighten predators or to make them suddenly "vanish" when the legs are folded.
- The bullfrogs are quite aggressive and will not hesitate to attack and bite (even humans) with their tooth-like projections and powerful jaws. Rain frogs will inflate their bodies to make themselves look bigger while rubber frogs will stand up with straight legs to achieve the same effect.

❖ The major threat to amphibia today is the **destruction of wetland habitats**, and the accumulation of **toxins** in the environment, to which they are particularly sensitive. Their sensitive skins and the fact that they breed in water, make them susceptible to even small changes in water quality. For this reason, frogs are **a good indicator of environmental health.** If the numbers of frogs in an area suddenly **declines**, then something is badly wrong in the ecosystem. Pesticides and flawed frogs (see picture below):

