Reproduction (not anatomy).

(We're following the text fairly closely here, though not in as much detail - there's just way too much stuff in the text).

Sperm transfer:

External:

Varies; in almost all frogs and some salamanders, this is external.

In frogs, male positions cloaca near female cloaca ("amplexus").

A variety of positions can be taken.

Internal:

Frogs: other than *Aspcaphus*, a few members of the Bufonidae have internal fertilization (by cloacal apposition).

Salamanders: males deposit "spermatophores". Mushroom like stalks with sperm at the top.

Through complicated sequences of interactions (termed "Liebestanz" or "Liebesspiel" (tr. "love dance") male gets female to move over spermatophores.

Female straddles the tail of the male, with head resting on hips.

Male raises tail, releases spermatophore, then moves forward.

Female follows and then picks up sperm packets with cloaca.

Reptiles all have internal fertilization (as discussed previously).

Nest building:

Not everyone builds nests.

Many frogs, and salamanders don't build nests:

Lay eggs in water and/or deposit them in good spots in the environment.

Remember that occasionally this may be in temporary pools or even in arboreal pools.

But some do build nests:

Foam nests used by several groups of frogs; eggs deposited in foam, which eventually dissolves.

In reptiles, most species will build some type of nest.

Nest building varies, from digging holes in moist logs, to actually constructing a nest (crocodylians). Usually look for moist areas since eggs do dry up some.

Crocodiles generally build above ground nests, deposit eggs, and often stand guard near the nest.

Turtles usually dig into soil, deposit eggs, then cover nests.

Chelodina rugosa (Northern snake necked turtle) may actually lay eggs in sand under water; Eggs don't start to develop until the dry season when water levels drop.

Lizards and snakes usually pick sites that are hidden and somewhat damp (rotting logs, soil, etc.).

Some snakes (e.g. some pythons) will coil around eggs to raise the temperature.

Incidentally, depending on the species, many hatchlings (particularly in turtles) may overwinter in the nest before emerging to forage.

(Most emerge later in the year).

Sex determination.

Although many reptiles do use genetic determination (either an XY/XX system or ZZ/ZW system), many species have sex determined by tempreature.

Depending on the temperature, hatchlings develop either into males or females.

Usually the changeover is fairly abrupt (i.e., hatchlings will be mostly male or mostly female).

Generally, higher temperatures mean males in crocodiles and lizards, but females in turtles.

However, this is quite variable.

Sex determination happens in the “second trimester”.

Fairly wide spread.

Surprisingly, even found in some viviparous species (e.g., some skinks).

Has led to speculation that female can manipulate sex of offspring.

Some evidence that this is true.

There is recent speculation that global warming might have a negative impact on survival of many reptiles as this may lead to production of mostly one sex.

(A quick glance at some of the titles of these articles seems to indicate that this might be a bit preliminary - it may be quite serious, but more work needs to be done).

Size of clutches and young:

We'll ignore most of this section in the text:

The basic idea is that there are two strategies:

Lots of young, with smaller size (r-selection).

Few young with bigger size (k-selection).

A species should pick whichever strategy maximizes survival (fitness).

So far so good, but then the text either states the obvious or becomes very speculative.

(E.g., as Ambystoma females get larger, they increase clutch and egg size)

(The text does point out that egg size is limited by the pelvic opening in turtles)

Seasonality:

This depends on the environment a lot.

In temperate areas or in tropical areas with distinct wet and dry seasons, many amphibians and reptiles will tie their reproductive cycles to the seasons.

Note that even for species that pick a particular time for reproduction, this may be spread out or very concentrated.

Amphibians:

Most amphibians will reproduce annually, but some will only reproduce every other year.

This can vary between sexes:

Plethodon kentucki: males breed every year, females every other year.

In the tropics, most amphibians will breed during the wet season (if there is one).

Otherwise may actually breed year round

Reptiles:

In temperate areas, most reptiles will breed in the spring.

Primarily due to cold season (hatchlings must get out and grow enough to survive winter).

As mentioned above, though, some hatchlings may overwinter.

Elsewhere, many reptiles will in some way tie reproduction to environmental factors such as moisture or availability of food.

As for amphibians, some reptiles reproduce nearly year round (but this is not too frequent).

Sexual vs. asexual reproduction:

Parthenogenesis is probably the best known asexual reproduction in amphibians and reptiles, but a few others should be briefly mentioned:

What your text calls hybridogenesis:

Occurs in some frogs (genus *Pelophylax*)

Two species hybridize, and produce a "species" called *P. esculenta*.

The process is fairly complicated (see text), but these hybrids will mate with either of the original parent species, but then through various genetic manipulations, produce more hybrids.

Just the hybrid genome makes it into the offspring of hybrids, not the genetic material from the parent species.

More hybrids are also produced by the parent species, of course.

Kleptogenesis

In some mole salamanders (*Ambystoma*), there are both regular diploid sexual individuals and unisexual polyploid individuals.

Somehow, the polyploid species can "steal" genetic information from normal males to increase survival.

Process isn't explained in your text.

(Presumably through some kind of false mating??)

Parthenogenesis

This is actually wide spread in the animal kingdom, and found not just in reptiles (e.g., sharks).

Found in numerous lizards, and one snake.

Essentially what happens is that the female lays a viable egg:

Chromosomes are doubled to get tetraploid precursor to egg; followed by normal meiosis.

So each egg winds up diploid and fully viable.

(Other groups of animals may do this differently).

A few variations on this are known, and some parthenogenetic species are actually triploid.

Most members of a parthenogentic species are genetically very similar.

Some species are “facultatively” parthenogenetic.

Usually reproduce “normally”, but can switch to parthenogenesis if “needed”

Komodo dragons were recently found to do this.

Pseudocopulation:

Female behaves as a male and “copulates” with the other female.

Causes hormonal changes that speed up the process of ovulation.

Seen more often in lab conditions, but has been observed in the wild.

Life history:

This section in your text focuses mostly on population ecology (which is arguably not really part of reproduction).

Let's quickly review survivorship curves:

Type I - high survivorship until older age

Type II - constant survivorship through all age groups

Type III - high juvenile mortality, then good survivorship until old age.

No amphibians or reptiles really have type I survivorship curves.

(Night lizard gets close).

Type II can be found particularly in several species (book isn't specific)

Type III is found in many (amphibian eggs and larva, but also turtles and crocs)

A bit surprising considering your crocs are watched over.

We're skipping over the last two sections in this chapter.

Much of it is trying to classify amphibians and reptiles into different type of survival strategies.

Difficult because the “survival strategies” are a bit arbitrary, and it's not always obvious if a specific species fits a particular strategy.

Still, some interesting examples you can look at yourself.

Reproductive modes - viviparity:

(As mentioned, your book does not distinguish ovoviviparous).

According to your text, this has evolved independently at least 113 times.

(Seems unlikely somehow).

Obvious advantage is that young are protected until emergence/hatching.

Text mentions that this may cause problems for the female (predator escape, food gathering, etc.).

Another advantage (at least in reptiles) is that the mother can better control the temperature for the offspring.

Complexity of what your text calls viviparity varies:

In some, young literally don't receive any nutrients from the mother (ovoviviparous).

In others, young get a fair amount of nutriets (some skinks even have a placenta that is somewhat similar to that found in mammals).

Parental care.

The advantage of parental care is fairly obvious - increased survival of the young. Of course it does mean a larger investment by the parents.

There are several types of parental care.

Nest attendance:

Some amphibians and reptiles will stay with the nest or eggs to help maintain the eggs. This does not include nest defense (see below). Aerating eggs, manipulating eggs, etc.

Nest guarding:

Adults will guard the nest and chase away predators (including often members of the same species). Obvious example is crocodiles, but also found in other species.

Transport of egg or young:

Eggs or young can be carried around by the parent (either sex). Generally just for transport (e.g., crocodiles transporting young).

Egg brooding:

Similar to above, but this time eggs are actually carried around until hatching (e.g., midwife toad, *Pipa pipa*, etc.

But can also refer to deliberately staying with eggs to enhance egg development (e.g., pythons that raise temperature of eggs)

Feeding young:

Some amphibians provide non-fertile eggs to help feed tadpoles.

Some will actually have two different kinds of tadpoles - the first group serves as food for the second.

Guarding young:

Fairly common. Many reptiles and amphibians will help guard their young for some time to aid their survival (crocs are the obvious example). Some adult frogs will stay near their young. Juvenile skinks (*Egernia saxatilis*) will remain in their parents territory.