De Generatione animalium

3.1.749a9-3.7.757b30

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The first seven chapters of GA 3 touch on sundry questions, including hermaphroditism in hyenas and oral impregnation in fish and ravens, but the driving concern is to understand the nature of eggs, their different varieties, and what is unique about those cases of animal generation that involve them. Throughout this investigation Aristotle returns again and again to the looming prospect of generation without fecundation in egg-bearing animals, that is, to the variety of spontaneous generation that today we describe as 'parthenogenesis'. Aristotle denies its possibility in all cases, but this leaves him with the difficult task of explaining a number of peculiar natural phenomena: notably, that there are many animal species that do not seem to copulate at all, and, another, that eggs, which might be thought to contain the principles of both parents, can evidently be produced without a contribution from the father--in bony fish this happens as a rule, and in birds it happens exceptionally. A broader concern throughout these chapters is to place oviparous animals within the larger hierarchy of relative 'perfection' that may be discerned in a species' mode of generation.

GA 3 illustrates yet another class of cases in which, for Aristotle, form separates from matter to the extent possible, and therefore in animals the more perfect a species, the more these principles will be distinct. In the cases here, the separation is discerned in two different sorts of egg, belonging to two different, hierarchically ordered animal kinds. In the bird kind, the egg is perfect at the moment of oviposition, which is to say that it has already attained its full size, while by contrast in oviparous fish the eggs are imperfect when laid, which is to say that they will continue to grow (1.8.718b16-19; 3.1751a25-28). In birds moreover the egg is separated into the white (τὸ λευκὸν) and the yolk (τὸ ὠχρὸν), where the white is held to contain the vital principle or soul-heat, and the yolk its material nutriment. In fish, eggs are all of the same consistency, and thus visibly not separated into two principles. It is, in most

[1] Many thanks to G. E. R. Lloyd, Stephen Menn, and Ina Goy for their very constructive comments on this paper in its present written form. Thanks also to the participants at the conference on Aristotle's *On the Generation of Animals* at the University of Tübingen, May 3-5, 2017, especially Emily Jane Perry and James Wilberding, for their helpful feedback on an earlier draft.

general terms, the animals that bring forth young in a state closest to the adult that is more perfect, and this is why birds are more perfect than fish, and also, though beyond the scope of the present chapter, why viviparous animals are more perfect than oviparous ones. Yet things can get messy in nature, and Aristotle is certainly a sufficiently lucid observer to recognize as much.

There are in fact four broad classes of animal whose reproduction is of interest in the present section: not just the reproduction of birds (treated in 3.1 and 3.2); and of egg-laying fish (3.4-3.5); but also of 'oviparous quadrupeds' , which is to say lizards, crocodiles, and like beings today known as 'reptiles' (treated in passing in 3.2.753a1-17, these animals pose no conceptual problems distinct from those of birds, and differ from these latter with respect to reproduction only in that they do not incubate their eggs, sitting on them only for their security, and not for the sake of heat); and, finally, of selachians (3.3), which is to say sharks, skates, rays, and other cartilaginous fishes, as well as some other species of fish misclassified among these, such as the *Lophius piscatorius*, called by us the 'angler' and by him the 'fishing frog' (3.3.754a21-25). Aristotle is perplexed to find that these latter lay eggs, unlike the other selachians, but does not consider this fact as evidence that they are not, in fact, selachians at all. Animals of the first three varieties are oviparous, while selachians (as well as vipers, which are not treated in Book 3, see 2.1.732b21) are 'ovoviviparous', that is, they are "internally oviparous but bring forth their young alive, after the egg has moved from one position in the uterus to the other" (3.1.749a19-22). This egg is, like other fish eggs, but unlike the eggs of birds and of ovoviviparous animals, "soft-shelled and of one colour only" (3.1.749a22-23). The non-selachian fish egg is like that of the shark in this regard, yet unlike it in that its perfection takes place away from the parent (3.1.749a25-26). Thus, to summarize:

	Egg perfect when laid	Egg imperfect when laid	Egg perfected internally, but young born live
Birds and 'egg-laying quadrupeds' (reptiles with feet)	x		
Non-selachian fish		x	
Most selachians and vipers			x

In what follows I will offer an interpretation of the first seven chapters of Book 3 of the GA, which does not directly follow the order of topics Aristotle addresses. This approach is

justified insofar as Aristotle himself jumps around considerably, focusing on wind-eggs, for example, in both 3.1 and again in 3.7.[2] It is useful to read these chapters as taking up a set of problems that, if unresolved, would seem to contradict Aristotle's general account of a hierarchical order of nature in which more perfect animal kinds manifest their relative perfection through the relative perfection of their young, and in which generation across all kinds under consideration here involves the combination of a separate formative principle from the male and a material principle from the female. Some of these problems arise from phenomena Aristotle acknowledges to be real, such as wind-eggs in birds and ovoviviparity in selachian fishes, while other problems arise from phenomena, such as hermaphroditism in hyenas and self-fertilization in the mysterious *trochos*, that Aristotle denies. His task in the latter case is to explain why such things could not happen, and in the former case to explain why such things, though they happen, do not compromise his overall theoretical account.

Aristotle devotes far more space in these chapters to the threats to his account of bird, reptile, and fish reproduction than he does to the account itself: more attention to wind-eggs than to normal avian oviparity, more attention to selachian ovoviviparity than to fish in general. Accordingly, the first two sections will focus on these two matters respectively. In a third section I will focus on phenomena that Aristotle denies, as treated in the final sections of 3.5., concerning erroneous views on fish reproduction and on fish sexual dimorphism, as well as in all of 3.6., concerning various erroneous views of generation in birds and mammals. I will conclude with some brief remarks on the place of Aristotle's account of the generation of birds and fish within his broader theory of the generation of animals, and indeed of generation in general.

1. ζεφύρια and Other Bird Eggs (3.1-3.2)

[2] For discussion of wind-eggs earlier in the GA, see 1.21.730a5-16 (in which Aristotle deploys observations on wind-eggs in the service of his extended argument against the doctrine that semen comes from the entire body of the male), and 2.3.737a30-34. See also HA 6.2: "Such as affirm that wind eggs are the residue of eggs previously begotten from copulation are mistaken in their assertion, for we have cases well authenticated where chickens of the common hen and goose have laid wind eggs without ever having been subjected to copulation... wind eggs are laid by a number of birds; as for instance by the common hen, the hen partridge, the hen pigeon, the peahen, the goose and the vulpanser."

It will be helpful in the present section, where our true purpose is to understand Aristotle's claims in GA 3.1-7, to consider as well both the broader history of popular lore concerning wind-eggs and related phenomena, and also to consider the current scientific consensus on the biology of unfertilized bird eggs, their origins and causes. To do so is not gratuitous digression, but a necessary part of placing Aristotle's own observations and interpretations in relation to the twin legacies of the history of popular lore and the history of science, and so to discern where Aristotle is allowing himself to passively channel the lore, and where by contrast he is discerning some real process in nature.

One immediate challenge for the interpreter is that 'wind-egg' has meant several different things in the history of poultry breeding. Contrary to a certain misconception, such an egg is not associated with wind to the extent that it is hollow and filled with air (as is implied in the idea of a 'wind-bag'). In fact on all understandings a wind-egg is quite full. 'Wind' modifies 'egg' here not in the sense that the egg is 'windy', but in the sense that it is 'wind-caused': thus a modifier more like the first element of 'sea glass' than of 'milk chocolate'. The wind in question is the west wind, embodied by Zephyros, one of the four ἄνεμοι or wind deities, who emerges from his cave at the beginning of spring and stirs up a gentle breeze that brings buds and leaves to the trees and verdancy to the ground.

In post-classical usage, the entity in question is also described as a 'witch egg', a 'cock egg', and a 'dwarf egg': the first two terms, like 'wind egg', involving a causal theory, while the latter involves only a description. Various defects in the egg can earn any one of these appellations: having an absent or underdeveloped yolk, lacking a shell, and, by far the most common, being abnormally small. All of these traits are interpreted as signs that the egg is incapable of maturing. In a 1966 study in *Nature* it was determined that around 0.1 percent of chicken eggs are of this sort.[3]

[3] See K. A. Rookledge and P. J. Heald, "Dwarf Eggs and the Timing of Ovulation in the Domestic Fowl," in *Nature* 5043 (June 25, 1966): 1371. The authors draw heavily on the earlier work of Raymond Pearl and Maynie R. Curtis, "Studies on the Physiology of Reproduction in the Domestic Fowl-- XV. Dwarf Eggs," in *Journal of Agricultural Research* VI (April-September, 1916): 977-1042.

The modern popular belief that wind-eggs are laid by male birds --thus, 'cock eggs'-- seems to arise from the fact that they are without yolk, and thus may appear to be entirely filled with a sort of clear seminal fluid. Pearl and Curtis observe in 1916 that a "widespread superstition which comes down nearly to our own time is that a cock, or especially a very old cock, produces these eggs. These 'cock' eggs were sometimes supposed to be made up of semen and 'humors'."[4] The true cause of yolklessness appears to be that the egg-producing glands are activated, so to speak by mistake, and some free-floating bit of tissue in the hen's body is encased in albumen and a hard shell as if it were a yolk.

If they are associated with Zephyros, this is because wind-eggs tend to appear in March, April, and May, and these, in turn, tend to be the first attempts at laying by young hens.[5] In the HA, Aristotle himself identifies only those defective eggs produced in spring as ζεφύρια, while calling the ones produced in summer οὔρια, which is to say, simply, 'rotten' (HA 560a). We have, in short, a long list of names describing a number of conditions, only partially overlapping, in which eggs might be found --atypically small, a missing or underdeveloped yolk, lacking a shell, rotten-- all attributed to a number of different causes, some solidly based in empirical observation, some in fantastical legend. Leaving aside interference from later sources and from popular lore about cock eggs and dwarf eggs, we may narrow the classical notion of wind-egg down to that which is conceptualized as a sort of spontaneous generation, even though it comes from a hen, to the extent that it is 'conceived' by nature itself, by the wind, rather than by sexual fecundation, or by the combination of the principles of matter and form of a particular animal kind.

The west wind was often held until the 17th century to operate *in loco patris* not only in the case of oviparous animals, but also of viviparous quadrupeds. Thus Pliny reports of mares in Portugal that, "when a west wind is blowing, stand facing towards it and conceive the breath of life." This, he explains, "produces a foal, and this is the way to breed a very swift colt, but

[4] Pearl and Curtis, "Studies on the Physiology of Reproduction in the Domestic Fowl," 977.

[5] Richard König-Warthausen, "Über die Gestalt der Vogeleier und über deren Monstrositäten," in *Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg* 41 (1885): 289-305, 294.

it does not live more than three years."[6] The locus classicus for this theory is in the *Iliad*, where Boreas (thus not the west wind but the north wind) disguises himself as a stallion in order to cover three thousand mares with which he was enamoured (Bk. 20). And Aristotle himself, in the HA, will report that "the mare is said also... to get wind-impregnated if not impregnated by the stallion" (HA 6.18.572a). These horses' premature death, to which Pliny alludes, is analogous to the wind-egg's tendency to expire prior to developing into a bird, as if both instances of a general law, that you can get *something* from an atypical conception, but in the end the production will prove to be defective and short-lived, demonstrating the superiority of sexual reproduction as the natural continuation of the cycle of like begetting like.

The scholarship on anemophilic impregnation is not abundant. An article of 1936 entitled "Animals Impregnated by the Wind," by the botanist and historian of science Conway Zirkle, while short on interpretation, does provide a remarkable compendium of citations from works dating from archaic Greek literature to early modern science.[7] Curiously, Zirkle cites a 17th-century *Historia naturae* by Joannis Nieremberg as evidence that, after centuries of myth-mongering, nascent modern science was finally beginning to cast doubt on the myth of the wind-impregnated mare. But in fact Nieremberg's story confirms our general account of ancient views as well. He tells us of a farmer in Portugal, beside the Tagus river mentioned by Pliny, who "had a pretty horse and wished to have her very saleable at the next markets," and so "shut her up alone on the island in the middle of the Tagus to fatten her with abundant food. After two months he discovered her pregnant and was astounded because no stallion had ever had access to her." After another seven months "she gave birth, not to an animal indeed but to an unformed mass of bloody concretion which he thought to be an abortion."[8] Whether it is a mere *mola* (see 4.7.776a, and below) or a proper foal that lives to the age of

[6] Pliny, *Natural History* 8.67 166. "Constat in Lusitania circa Olisiponem oppidum et Tagum amnem equas favonio flante obversas animalem concipere spiritum, idque partum fieri et gigni pernicissimum ita, sed triennium vitae non excedere."

[7] Conway Zirkle, "Animals Impregnated by the Wind," *Isis* 25, 1 (May, 1936): 95-130.

[8] Joannis Eusebius Nieremberg, *Historia naturae, maxime peregrinae, libris XVI distincta*, Antwerp: Ex Officina Plantiniana Balthasaris Moreti, 1635 Bk. I, ch. 66, 410a; cited in Zirkle, "Animals Impregnated by the Wind," 104. Zirkle cites the 1675 edition, not the original of 1635. We have consulted both, and found no difference between them.

three, these are just different extremes of a range of relative defectiveness. But no wind-conceived creature can exist entirely outside of this range.

The demise of speculative theories of wind-borne fecundating powers will occur over the course of the 17th century, in large part because this era was intent on discovering the microscopic physical bodies lying behind and explaining nature's powers. The search for the bodies behind the power of wind to generate living beings would ultimately bring about a transfer the focus of such theories from the zoological to the botanical realm. In the 1694 *De sexu plantarum*, published in Tübingen, Rudolf Jakob Camerarius attributes to Aristotle the view that "in springtime the birds seem to receive a fertilizing breath from the west wind."[9] He also cites the famous passage of Virgil's *Georgics*[10] in which we find mares being similarly impregnated, after which he remarks that "these words can be applied better to the conception of plants than to that of animals, for the latter, although they may be moved and stimulated by the wind, receive no germ from it, but plants owe much more to the wind because in the spring, their organs of conception are directed to the Zephyr like so many nostrils to inhale the rustling airs and flower dust. Impregnated by the wind's breath."[11] A plant that is generated in this way is so because a male principle is physically carried through the air, while nothing could be generated among animals by this means, Camerarius writes, "other than a sterile thing, a wind egg, a misbirth."[12] Camerarius's account is not quite correct. It is not that the ancients were ignorant of the fecundating power of the wind in the case of plants: Zephyros was responsible not just for wind-eggs and for pregnant mares, but also for the verdancy of springtime. It is simply that what was missing, in the case of both plants and animals, was a theory of microorganic bodies, such as pollen, travelling on the wind causing the fecundation, rather than the wind itself being the agent, and the absence of these physical

[9] Rudolf Jakob Camerarius, *De sexu plantarum epistola*, Tübingen: Typis Viduae Rommeii, 1694, 55-56.

[10] See Virgil, *Georgics*, Book 3: "Continuoque avidis ubi subdita flamma medullis, / Vere magis: quia vere redit calor ossibus: illae / ore omnes versae in Zephyrum stant rupibus altis, / exceptantque levis auras et saepe sine ullis / coniugiis vento gravidae, mirabile dictu, / saxa per et scopulos et depressas convallis / diffugiunt, non, Eure, tuos, neque solis ad ortus, in Borean caurumque, aut unde nigerrimus auster / nascitur et pluvio contristat frigore caelum."

[11] Camerarius, *De sexu plantarum*, 56.

[12] Camerarius, *De sexu plantarum*, 57. "... nisi fatuus, Zephyrius, mola."

bodies made it difficult to discern the relevance of a dividing line between the different mechanisms of botanical generation on the one hand and zoological on the other.

We have seen Nieremberg speak of 'abortion' (*abortum*) and Camerarius of 'misbirth' (*mola*). In Book 4 of the GA Aristotle explains that the production of such things "has been known to happen, in the case of a woman who has had intercourse and thinks she has conceived, that her figure has increased to begin with, and all the rest has proceeded as expected, but when the time for her delivery was at hand, she has neither brought anything to birth nor yet has the size of her girth decreased; instead, she has continued in that condition for three or four years, till she was seized with a dysentery which brought her to a dangerous pass, and then she has produced a fleshy mass, known as a '*mola*'" (4.7.776a). Aristotle describes this discharged object as "so hard that it is difficult to cut them in two even by means of an iron edge." He explains that the cause of such a fetation is "exactly the same as that of meat, when it is undercooked; and it is due not to heat, as some people allege, but rather to weakness of heat (because it looks as though Nature in these cases suffers from some inability, and is unable to complete her work and to bring the process of formation to its consummation." Here, Aristotle contends that the *mola* is produced by human women alone, since "alone of all animals woman are liable to uterine affections; they produce an excess of menstrual evacuations and cannot concoct them; and so, when the fetation has been 'set', formed out of a liquid which is difficult to concoct, then what is called the *mola* is produced." Yet, plainly, as Camerarius discerns, there is a natural connection between *mola* and wind-eggs: both are the product of excess residue, and both demonstrate what results when nature is unable to 'complete her work' on this residue. They are, we might say, species of a broader genus of uncompletable fetations, observable in different forms in all animals.

As we are seeing, to understand the causes and nature of wind-eggs and related phenomena is to understand, precisely, the limits of generation in the absence of a formative principle contributed by the father, and so, more broadly, to understand the necessity of the dual roles of matter and form in generation. In the treatment of wind-eggs we also see Aristotle reasoning in a way that some scholars have thought to be an innovation of modern science:

through teratology, namely, through attention to abnormal cases, he sees a key to better understanding what happens in the regular course of things the majority of the time.[13]

While it is likely impossible to determine the extent to which Aristotle has been influenced by the metaphorical evocation of wind eggs by Plato in the *Theaetetus* (210b), it is at least worth noting that Socrates's account of what a wind egg is lines up more or less directly with what we have seen so far: a wind egg is what is brought forth when there is no soul in the animal, or in the example of interest to Socrates, no conception of reason to give life to the words. There still is some sort of offspring, however, some sort of animal in Aristotle's case, and some sort of assemblage of words having the appearance of reason, in Socrates'. There is something there, in both cases, just not something that is sufficiently healthy or sufficiently well-ordered to survive

> **Socrates**: Are we then, my friend, still pregnant and in travail with knowledge, or have we brought forth everything?
> **Theaetetus**: Yes, we have, and, by Zeus, Socrates, with your help I have already said more than there was in me.
> **Socrates**: Then does our art of midwifery declare to us that all the offspring that have been born are mere wind-eggs [ἀνεμιαῖα] and not worth rearing?
> **Theaetetus**: It does, decidedly.

The term Socrates uses is not the same as the one in Aristotle; it is a substantivized adjective meaning 'windy', and thus 'something that is windy', and thus, by implication, a 'wind-egg'. [14] This form also has an established usage to designate anything that is empty or vain.[15]

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[13] For a classic statement of this thesis about modern science, see Lorraine Daston and Katharine Park, *Wonders and the Order of Nature, 1150-1750*, Zone Books, 1998.

[14] See David D. Leitao, *The Pregnant Male as Myth and Metaphor in Classical Greek Literature*, Cambridge University Press, 2012, 256. "Although Plato does not allude to the fertility of the wind in the midwife passage, where Socrates suggests that Theaetetus might give birth to a wind egg (151e6), he certainly does in the passage a bit later when he suggests that the wind brings life. Here Plato writes: 'Now shall I go on and mention to you also windless air [νηνεμίας], calm sea, and all that sort of thing, and say that stillness causes decay and destruction and that the opposite brings preservation'" (153c7-9).

Wind-eggs were a common enough symbol in Greek thought to be deployed in an ironic and metaphorical way,[16] and it seems certain that in the majority of its occurrences it is not intended as part of a straightforward account of the power of wind to generate eggs. In any case few ancient naturalists who write on wind-eggs believe that they really are conceived by Zephyros. Pliny for his part is happy to report hearsay about wind-impregnated mares, but when it comes to offering his own account of unfecundated generations in birds, he plainly prefers to follow Arisotle rather than Virgil or Homer. Pliny suggests that they are "conceived by the hen birds mating together in a pretence of sexual intercourse"[17] (it is worth noting here that female pseudo-copulation can in fact induce parthenogenetic reproduction in some species of lizard.[18]) It follows from the fact that wind-eggs are not true conceptions that they will be in some way defective. Pliny describes them as "of smaller size and less agreeable flavour, and more watery."[19] This seems a near-paraphrase of Aristotle's own remark in 3.1 that "their size is smaller. They are less pleasant to eat because they are more unconcocted [ἀπεπτότερα]" (3.1.750b24-26).

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[15] See Arar.6, *Com.Adesp.5 D.*, Ath.2.57e*; Them.Or.32.356a.*

[16] An ungerminated egg also figures in the cosmogony related by the chorus in Aristophanes's *Birds*: Χάος ἦν καὶ Νὺξ Ἔρεβός τε μέλαν πρῶτον καὶ Τάρταρος εὐρύς, γῆ δ' οὐδ' ἀὴρ οὐδ' οὐρανὸς ἦν: Ἐρέβους δ' ἐν ἀπείροσι κόλποις τίκτει πρώτιστον ὑπηνέμιον Νὺξ ἡ μελανόπτερος ᾠόν, ἐξ οὗ περιτελλομέναις ὥραις ἔβλαστεν Ἔρως ὁ ποθεινός, στίλβων νῶτον πτερύγοιν χρυσαῖν, εἰκὼς ἀνεμώκεσι δίναις (Aristophanes, *Birds* 695).

[17] Pliny, *Natural History* 10.80 166-67. "Inrita ova, quae hypenemia diximus, aut mutua foeminae inter se libidinis imaginatione concipiunt, aut pulvere, nec columbae tantum, sed et gallinae, perdices, pavones, anseres, chenalopeces. Sunt autem sterilia, et minora ac minus iucundi saporis et magis umida. Quidam et vento putant ea generari, qua de causa etiam zephyria appellantur; urina autem vere tantum fiunt incubatione derelicta, quae alii cynosura dixere. Ova aceto macerata in tantum emolliuntur ut per annulos transeant." Pliny is drawing here on Varro's *De rustica* 2.1.

[18] See D. Crews and K. Fitzgerald, "'Sexual' Behavior in Parthenogenetic Lizards (*Cnemidophorus*)," *Proceedings of the National Academy of Sciences* 77 (1980): 499-502.

[19] Ibid.

But what are the causes of wind-eggs, for Aristotle, if not the charge of fecundity Zephyros injects into his wind when he emerges from his cave in springtime? "They occur," he explains,

> in those birds which are neither good fliers nor crook-taloned [i.e., hawks and falcons] but which are prolific [τοῖς πολυγόνοις]. The reason is: (a) these have a great deal of residue, whereas in the crook-taloned birds this secretion is diverted to produce wings and wing feathers and their body is small and solid and hot; and (b) the menstrual secretion and the male semen are residue; therefore, as both feathers and semen alike are formed out of residue, Nature cannot provide a large supply for both purposes (3.1.749b2-9).

Wind-eggs are, in short, the product of excess residue. They arise in species in which there is no natural discharge of excess genital fluid, and no anatomical production to which they may be diverted, such as strong talons for catching prey or strong wings for flying. Some paragraphs later (3.1.750b3-7) he repeats the claim that wind-eggs are formed because birds do not discharge menstrual fluid as vivipara do, yet the unfecundated female principle must nonetheless be used up in some way or other. Here, in his second statement of the causes of wind-eggs, Aristotle refers to 'birds' in general, and does not repeat the earlier disjunctive explanation, that females animals must either menstruate, or, as in the case of hawks and falcons, have sufficiently imposing anatomical requirements that all of the female's residue may be diverted to the development of fertilized eggs, without any left over with no other outlet but inside a wind-egg. There are birds, such as the cuckoo, that are not good fliers and not crook-taloned, yet also do not produce wind-eggs, as they are 'cold by nature' and therefore less prolific (3.1.750a11-16). The most notorious wind-egg layer is the domestic hen, which is, not surprisingly, also the most closely observed of birds.

For Aristotle it is the white of the egg, and not the yolk, that contains the vital, and thus formal, and thus male principle. Aristotle writes:

> The white... does not congeal as a result of frost, but tends rather to become fluid; ... and when subjected to fire, it becomes solid. This is why, when it is concocted in connexion with the generation of the young animals, it thickens; for it is the white out of which the animal forms and develops, while the yolk becomes nourishment for it, and is the

> source from which the parts as they are formed at the various stages derive their growth. That, too, is why the yolk and the white are kept distinct and separate from each other by membranes, as having a different nature from each other (3.2.753b 8-14).

Rookledge and Heald report that yolklessness in dwarf eggs was only discovered in the early modern period, and indeed as we have seen Aristotle himself plainly describes the wind egg as consisting in both a white and a yolk. The presence of the yolk in an unfertilized egg is easy to account for, since Aristotle believes, as we have seen, that the yolk is the nutriment for the future bird, and not the location of the source of the soul-heat. Thus one might more reasonably expect a wind egg to be all yolk, than to be all white. But Aristotle explains that both of the two elements in the perfect egg come from the mother, "and the real difference is that one is cold and the other hot" (3.1.751b27-28). Aristotle contradicts both the majority of his predecessors,[20] as well (if this matters) as scientific truth in his view of the yolk as nutriment, the white as primordium of the future animal. In a normal bird egg, Aristotle believes, the principle is located in the white, but it is different from the rest of the white, and it is found near the narrower end of the egg, where the shell is harder and it is better protected. This principle is a theoretical entity for Aristotle. William Harvey would identify the cicatricula of the egg in his *Exercitationes de generatione animalium* of 1651, which would render such a principle more than merely theoretical, and would thereby permanently remove it from the white to the yolk.[21]

In GA 3.2.753a21-23, as well as in HA 560a, Aristotle explains that οὔρια differ from vernal zephyrs in that they tend to be produced in the hot summer season, and are caused to putrefy

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[20] See for example the Hippocratic treatise *On the Nature of the Child*: γίνεται δὲ ἐκ τοῦ χλωροῦ τοῦ ᾠοῦ, τροφὴ δὲ καὶ αὔξησίς ἐστιν ἀπὸ τοῦ λευκοῦ τοῦ ἐν τῷ ᾠῷ ἐόντος (Littré VII 536, 30; Louis n. 222).

[21] See William Harvey, *Exercitationes de generatione animalium*, London: Octavianus Pulleyn, 1651, Exercitatio 43, 120. "Fallitur Fabricius, circa materiam generationis Pulli in Ovo', 120. "In ovo igitur (ut diximus) nulla pars distincta, aut materia praeparata adest, ex qua foetus efformetur: sed quemadmodum in plantarum seminibus, aut gemmula protruditur; ita pariter in ovo, cicatricula, sive macula inest, quae vi plastica imbuta, in oculum & colliquamentum crescit; ex quo, & in quo pulli primordia, (sanguis scil. & punctum saliens) generantur, nutriuntur, & augentur in pullum perfectum."

by the heat. Unlike zephyrs, which are produced almost entirely by 'non-fliers', οὖρια are produced by crook-taloned birds as well, because they "are hot in their nature" (3.1.753a34-35). Pliny and later commentators appear to have mistakenly read Aristotle's οὖριον ('rotten') as οὖρον, and thus rendered it in Latin as 'urina'. Pliny distinguishes between the 'urina' or 'cynosura' on the one hand, and what is called the 'wind-egg' or 'Zephyr' on the other: "Quidam et vento putant ea generari, qua de causa etiam zephyria appellantur; urina autem vere tantum fiunt incubatione derelicta, quae alii cynosura dixere." Revealingly, in his edition and translation of Pliny, Harris Rackham fails to note that 'urina' is here a technical term, synonymous with 'cynosura' and contrasted with ζεφύρια; indeed he leaves it out of the translation altogether: "Some people think they are actually generated by the wind, for which reason they are also called Zephyr's eggs; but wind-eggs are only produced in spring, when the hens have left off sitting: another name for them is addle eggs."[22] Pliny misreads Aristotle and then he is misread in turn: evidently later scholarship could not make sense of Pliny's injection of urine into the discussion of Aristotle on eggs, and so preferred to gloss over it. But this in turn made it appear that addle-eggs and wind-eggs are the same thing, whereas they are plainly and significantly different. Aristotle does not think that addle-eggs contain urine. They result rather from excessively rapid concoction, while, as we have seen, it is in the nature of wind-eggs to be relatively unconcocted. Later, in 3.5, as we will discuss below, Aristotle argues that fish milt that travels into the stomach could not possibly result in the generation of an animal, since "whatever goes down into the stomach must of necessity be turned into nourishment, because it undergoes concoction" (3.5.756b8-13). It is the relative absence of concoction in wind-eggs that causes them to be small and watery with underdeveloped or perhaps even absent yolks, which are in turn the nourishment for the developing bird. Addle-eggs are not short on nourishment, but they get spoiled through excessively rapid concoction.

Between the two extremes of excessive and insufficient concoction, there is the healthy egg, which may be hoped to develop into an adult bird. Aristotle observed its organic structure with remarkable acuity. Bird eggs are remarkably uniform in structure, other than biologically insignificant differences in size and in the color of the shell. In addition to the yolk and the white within the shell, there is a membrane, called the 'vitelline membrane', surrounding the yolk, and two further membranes, the 'outer' and the 'inner', separating the white from the

[22] Pliny, *Natural History* 10.80 166-167.

shell. One variety of defective egg, which König-Warthausen reads Aristotle as placing among the varieties of wind-eggs, is the egg laid without a hard outer shell, and contained only in a soft membrane.[23] There is also a structure within both the yolk and the white of which Aristotle is largely unaware. He does observe the so-called chalazae tissues within the white, which he refers to as being like an umbilical cord, and visible particularly in eggs with chicks that are aborted prior to hatching (3.2.752b4-7). As mentioned, Aristotle does not discern any structure in yolk, notably missing the germinal area that Harvey would later identify as the primordium of the embryo. Instead for him the 'principle' (ἡ αρχή) is found in the white: this, Aristotle maintains, is 'the hot part', which is "closer to the form of developing creature" (τὸ μὲν οὖν ἐστὶν ἐγγύτερον αὐτοῦ τῆς μορφῆς τῶν [μορίων] γινομένων, τὸ θερμόν) (3.1.751b1-3). The first organ to form from the principle is the heart, and once it has formed the 'Great Blood-vessel' (μεγάλη φλέψ) or vena cava separates off from it. From this vessel there develop two structures that Aristotle identifies as 'umbilical cords' (ὀμφαλοὶ), one extending "to the membrane which surrounds the yolk, the other to the chorion-like membrane which surrounds the animal on all sides" (3.2.753b19-23). The membranes are the vitelline and the eggshell membrane respectively, and the two cords in question may be identified, again respectively, as the yolk-sac stalk and the allantois.

Aristotle correctly discerns that the first of these cords is responsible for supplying nourishment to the embryo, and reasons analogically that the condition of the embryo in relation to the yolk is comparable to that of a plant to the ground. This relationship, of plant to ground, is in turn fundamentally the same as that of the fetus of a viviparous animal to its mother, though what is special in the case of oviparous animals is that "since the nourishment of the oviparously formed embryos is not completed within the mother, when they leave her they take a part of her out with them" (3.2.753b31-35). The second cord, connecting to the eggshell membrane, which Aristotle sees as 'blood-like' (αἱματώδη), bears a relationship to its membrane comparable to that of the viviparous fetus to the uterus (3.2.753b35-754a1). From these comparisons Aristotle moves on to a far more audacious one: that the perfect bird egg, rather than being contained within a uterus within its mother, contains within itself both the

[23] See König-Warthausen, "Über die Gestalt der Vogeleier und über deren Monstrositäten," 294. The author faults Aristotle for purportedly characterizing eggs without a shell as 'Fliess- oder Windeier (ova sine putamine s. mollia)', when in fact, he argues, "they should preferably be called *ova nuda*."

uterus and, in a sense, the mother: it is as though you were to envelop both a viviparously produced embryo and its mother entire" (3.2.754a1-4). He goes on to suggest that the mother "is in the uterus, you might say, because in this case that which comes from the mother is the yolk" (3.2.754a6-7). The reason for this "is that the embryo's period of nourishment does not reach completion within the mother" (3.2.754a8-9).

Although in the end oviparity is a less perfect mode of generation than viviparity, the bird egg is nonetheless, as we have seen, in its own way perfect. In these comparisons between the viviparous mother on the one hand and the egg on the other --the mother contained within the uterus, vs. the uterus contained within the mother--, it is hard not to detect in Aristotle a certain ambivalence, a perception that the bird egg is not just relatively perfect among ovipares, but absolutely perfect. In the end however it is better to emerge from one's mother ready to live, sharing the form of adult representatives of one's species-- yet no adult animal is a perfectly hard, immobile spheroid. And so, however marvelous a structure a bird egg might be, it is not the best way to be born. To appreciate its relative perfection, in turn, it is illuminating to consider it in relation to the imperfect egg of the fish, and also, particularly, to the problematic case of the egg of the selachian fish, which never emerges at all from its mother's body. Let us then turn to these animals now, and to their modes of generation.

2. Selachians and Other Fishes (3.3-3.4)

"A female sand tiger gives birth to a baby that's already a metre long and an experienced killer," one elasmobranch biologist recently noted.[24] Since the mid-20th century it has been known that sharks of this species (*Carcharias taurus*), and perhaps others, engage in what is called 'adelphophagy', in which the strongest of a litter will devour its siblings *in utero*. What could be more perfect, in Aristotle's sense, than a large newborn animal with a morphology basically identical to its parents, and that has already mastered its species' characteristic activity prior to birth?

[24] Demian Chapman, quoted in Theo Tait's review of Juliet Eilperin, *Demon Fish: Travels through the Hidden World of Sharks*, Duckworth, 2012, in *London Review of Books* 34, 15 (August 2, 2012): 19-20.

Aristotle did not know about adelphophagy, though he did know about the rapaciousness of newborn sharks, and he did know, and think a great deal about ovoviviparity in sharks and other cartilaginous fish such as skates and rays. In Liliane Bodson's helpful reconstruction, this process involves four principal stages: (1) egg-cell formation in the female's ovary; (2) internal fertilization; (3) migration of the eggs through the oviduct to the shell gland, or nidamental gland; (4) discharge of the egg cases into the body cavity or the uterus, where the embryos are kept in separate uterine compartments for the entire period of gestation.[25]

Bodson is principally interested in Aristotle's treatment of shark reproduction in the HA 6.10, where he discusses the apparent ability of a class of sharks, the dogfish (οἱ γαλεοὶ), are able to "release and take in again" (ἐξαφιᾶσι καὶ δέχονται) their young.[26] It is not clear here whether this taking-in-again involves a return of the young to the birth canal, or rather a temporary shelter within the mother's mouth, but either way we have some sort of recognition that, as is clearly illustrated with marsupials, birth marks no clear break, and that there is rather significant continuity between gestation and neonatal care. On occasion Aristotle fails to correctly distinguish brooding behavior, of parents toward offspring in a secondary phase of their development, from simple gestation. Thus in the case of the βελόνη, presumably a pipe-fish such as the *Syngnathus acus,* and in the same family as seahorses, Aristotle observes the 'bursting asunder' (HA 567b23; see also GA 3.3.755a33-34), but does not notice that this is in fact the male, who has been protecting the eggs deposited by the female in his ventral pouch, and not the female giving birth. There is then a wide variety of adaptations for incubating eggs and for nurturing young animals in the marine environment, some of which Aristotle correctly observed, some of which he conjectured without in fact observing, and some of which he failed to notice.

In the case of birds, generation is more or less the same across all species (other than the fact that only a small minority of birds have penises, while in most species conception occurs

[25] Liliane Bodson, "Aristotle's Statement on the Reproduction of Sharks," *Journal of the History of Biology* 16, 3 (Fall, 1983): 391-407, 401.

[26] See Liliane Bodson, "L'incubation bucco-pharyngienne de *Sarotherodon niloticus* (Pisces: Ciclidae) dans la tradition grecque ancienne," *Archives internationales d'histoire des sciences* 31 (1981): 5-25; see also J. R. Oppenheimer, "Mouthbreeding in Fishes," *Animal Behavior* 18 (1970): 493-503.

through what is called a 'cloacal kiss'), and in any case we know which birds Aristotle was observing most closely: the domestic chicken (*Gallus gallus domesticus*). In the case of marine vertebrates by contrast, there is often considerable difficulty in determining which species, exactly, the philosopher is observing. D'Arcy Wentworth Thompson made considerable progress in matching real fish species of the Eastern Mediterranean to Aristotle's descriptions, in his 1947 *Glossary of Greek Fishes*.[27]

There are only a few species described in the section of GA 3 on fish reproduction, in contrast with the HA in which several species are mentioned. There is the *Lophius piscatorius*, mistakenly classified as a selachian, and taken to be exceptional among selachians in that it is the only fish that is neither ovoviviparous nor lays imperfect eggs, but, like birds, lays perfect eggs. Aristotle's dogfish is the *Mustelus mustelus*, today more commonly known as the 'common smooth-hound', among other names.[28] This is the exemplar of the shark for Aristotle, and while he studies other species with diverse modes of reproduction, he takes *Mustelus* ovoviviparity as exemplary for all shark kinds. Aristotle incorrectly maintains that all selachians are ovoviviparous (other than the fishing frog, which, again, is not in fact a selachian). In fact many shark species do lay eggs, and among the ones that do not some are truly viviparous, while some are ovoviviparous, or, to use contemporary language, some are truly placental while others are aplacental and nourished by the yolk-sac within the egg within the mother's body.[29]

Selachian eggs lack an external shell, as they do not need one, since the mother is their source of protection. Lacking an outer shell, they also lack an eggshell membrane, and so too they lack the second 'umbilical cord', the allantois, that Aristotle had identified in birds, and that he had assumed connected the embryo to the outer membrane as the bird egg's equivalent to a

[27] D'Arcy Wentworth Thompson, *Glossary of Greek Fishes*, London, 1947.

[28] Müller identifies the 'smooth shark' or smooth dog-fish according to a now archaic name, not as *Mustelus mustelus*, but as *Galeus laevis*.

[29] See. W. C. Hamlett. *Sharks, Skates, and Rays: The Biology of Elasmobranch Fishes*, Baltimore: The Johns Hopkins Press, 1999; Leo S. Demski and John P. Wourms (eds.), *The Reproduction and Development of Sharks, Skates, Rays and Ratfishes*, Dordrecht: Kluwer, 1993.

uterus.[30] In selachians, instead, the egg remains attached to the uterus, to the point of its ultimate perfection (3.3.754a-b). The eggshell membrane, recall, has something 'blood-like', and is the closest thing in the bird egg to the uterine lining. In sharks, by contrast, the nutritive material that the embryo takes in through its single umbilical cord in fact comes from the uterus and is akin to the placenta in mammals (although as we have seen it is considered 'aplacental' today). When Johannes Müller observed this structure in the *Mustelus mustelus* 1842 he was astounded to realize that Aristotle had discerned it millennia earlier, and that no one in the period between them had noticed it, let alone described it.[31]

If the egg is perfected even before it is hatched, how is selachian reproduction not more perfect than that of birds? After giving us a general account of selachian reproduction, Aristotle moves on to just this question. Any fish egg, selachian or non-selachian, is "single-coloured, the contents being mixed up together throughout, so that there is nothing to prevent the 'principle' in them being at the opposite end; the egg is of similar composition both at the end where it is fastened at the opposite end" (3.3.754b23-26). What explains the differentiation of the bird egg into yolk and white, as we have seen, is that it is perfect at the time of oviposition, and so the nourishment of the developing embryo has to be contained within it. In the selachian by contrast, the egg is perfected internally, and therefore, although the egg itself does not increase in size, the embryo within it does, as "it is easy for it to draw the nourishment out of the uterus by means of passages which lead from" the principle within the egg (3.3.754b26-27).[32] Aristotle seems to think that among egg-layers, it is a mark of

[30] See Johannes Müller, *Über den glatten Hai des Aristoteles, und über die Veschiedenheiten unter den Haifischen und Rochen in der Entwickelung des Eies*, Berlin: Druckerei der Königlichen Akademie der Wissenschaften, 1842, 10-11. "... die Fische nicht die Allantois der Vögel, wohl aber ihren Dottersack besitzen."

[31] Müller, *Über den glatten Hai des Aristotleles*, 5. "Aristoteles [hatte bereits] eine auffallend specielle Kenntniss von dem Vorkommen eierlegender und lebendiggebärender Thiere mit und ohne Mutterkuchen in einer und derselben Familie von Thieren."

[32] Müller makes precisely this observation: "Was die Fier der Eierlegenden theils in sich selbst, theils in der atmosphärischen Luft und in dem Wasser zu ihrer Entwickelung vorfinden, dafür haben die Eier der Lebendiggebärenden Äquivalente in dem mehr oder weniger innigen Verkehr mit dem mütterlichen Organismus" (Müller, *Über den glatten Hai des Aristoteles*, 3).

greater perfection to have differentiated functions within the egg itself, and so the fetal shark's connection to its mother's body, while a marker of the superiority of vivipares to ovipares, in turn is a marker of relative imperfection among ovipares, and sharks are a variety of ovipares.

In Nicolaus Steno's *Historia dissecti piscis ex canum genere*, a report on a 1667 anatomical study of a dogfish of some sort, perhaps a *Mustelus mustelus* but also possibly a member of the genus *Squalus*, or a 'spurdog', the Danish anatomist devotes most of his attention to the head, and most of all to the dentition, of the shark.[33] He does however devote over a page to the reproductive system. His principal concern is to answer the question whether the ovaries may be identified as the 'female testes', having the power to produce eggs, rather than the uterus, as researchers such as Harvey had believed. Steno drew from the observation of eggs in the 'female testes' of the shark the conclusion that some sort of egg develops in viviparous animals as well. "Having seen that the testicles of viviparous animals [i.e., dogfish] contained eggs," Steno writes, "and having noticed that their uterus opens into the abdomen, in the manner of the egg-duct, I no longer doubt that women's testicles are analogous to the ovary."[34]

As Steno's observations begin to reveal, ovoviviparity in fact looks a great deal like viviparity *tout court*, and for this reason Aristotle's deep conviction, that all fish must produce eggs, is remarkable. The internally perfected shark egg is more a membranous sac around the shark fetus, and at no stage in its development is the fetus disconnected from the mother, via the placentoid structure. In what sense then is this an egg, if we understand an egg to be that which makes possible fetal development apart from the mother? Aristotle's account of ovoviviparity seems a clear-cut case of theoretical commitments unduly influencing observation. In general (though he makes an exception, as we have seen, for fishing frogs or

[33] See Nicolaus Steno, *Elementorum myologiae specimen, seu Musculi descriptio geometrica. Cui accedunt Canis carchariae dissectum caput, et dissectus piscis ex canum genere*, Florence: Sub signo Stellae, 1667.

[34] Steno, *Dissectus piscis ex canum genere*, 117. "Inde vero, cum viderim, viviparorum testes ova in se continere; cum eorundem uterum itidem in abdomen, oviductus instar, apertum notarim; non amplius dubito, quin mulierum testes ovario analogi sint." See also Jacques Roger, *The Life Sciences in Eighteenth-Century French Thought*, tr. Robert Ellrich, Stanford: Stanford Uiversity Press, 1993 [1963], 207-08.

anglers), he thinks that "it would be odd" if a characteristic "were present in a portion of the group and not the whole of it" (3.4.755b36-756a2). In this particular passage he is writing about sexual dimorphism in fish, but the same point stands for egg-laying. All fish lay eggs; sharks are fish; therefore, sharks must lay eggs, and aplacental viviparity gets interpreted as a variety of oviparity.

The eggs of non-selachian fishes are 'imperfect', in that they continue to grow after being laid. This, Aristotle maintains, happens both 'of necessity' (ἐξ ἀνάγκης) and 'for the sake of what is better' (χάριν δὲ τοῦ βελτίονος) (3.4.755a23-24). The eggs could not all develop in the uterus, since all non-selachian fish are too 'prolific', too many eggs are produced for there to be room enough within. Corollary to their prolificness is the high mortality rate among fish in the egg stage: "Nature makes good the destruction by sheer weight of numbers" (ἀναμάχεται γὰρ ἡ φύσις τῷ πλήθει τὴν φθοράν) (3.4.755a32-33). Aristotle has no idea of adaptation of organism to environment, since there is no history to this 'making good'. It has just always been this way. But there is plainly something like a notion of fitness. The marine habitat is swarming with predator species, hungry for eggs. Nature has arranged an equilibrium between their appetite and the steady reproduction of their prey, such that there is no danger of either extinction or excessive increase in population.

The prolificness of fish is the source of the first of several erroneous theories of generation treated by Aristotle in GA 3.5-3.7. As has been his method in treating exceptional occurrences (e.g., wind-eggs), Aristotle discusses erroneous theories not to dispatch them as quickly as possible, but rather as a point of access for understanding what in fact happens in nature always or most of the time. Let us then turn to the final three chapters of the section of Book 3 under investigation.

3. Erroneous Theories (3.5-3.7)

All fish copulate. This claim is held up as a principle by Aristotle, not a mere conjecture. Although he recognizes he has only witnessed copulation in a small number of cases, still he believes that what holds of any must hold of all in matters of generation, if they are to be held to be members of the same kind at all.

Aristotle is mistaken. In fact a great number of fish species depend on external fertilization alone, in which the male sprinkles his milt on eggs that have already been deposited by the female. Yet he is also perfectly aware of this phenomenon, and indeed has observed it carefully. Why would the male need to go to this trouble if he has already fertilized the eggs prior to their release from the female's body? The answer lies in another false theory accepted by Aristotle, which involves not just an incorrect observation of the empirical facts, as in the claim that all fish copulate, but indeed a fairly significant, and consequential, misunderstanding of the biology of conception. It is, namely, the theory of superfetation, according to which genetic material can be added to a fetus already in the course of development, either by successive depositions from the same male, or by a series of distinct males. (While in no species is it possible that multiple fathers contribute to the development of a single offspring, in at least some sharks it is possible that different pups from the same litter will be, in effect, half-siblings, each having a different father.[35]) Aristotle believes that this is possible throughout the animal kingdom, and that, for example, a human child can inherit the traits of more than one father if the mother has relations with more than one man while pregnant. But he believes in turn that it must happen, if fish are to develop to maturity. In 3.7.--a section of Book 3 that returns to make relatively minor points about topics already introduced in the preceding sections-- Aristotle explains that in the case of both birds and fish, the perfecting of the egg is done by the male. In birds this occurs within the parent animal, but in fishes, "because the egg is in an imperfect state when it is deposited" (3.7.757a32-35), the perfecting must take place outside. In birds as well a sort of superfetation is the rule, as the female must be treaded multiple times in order for the egg to grow as it should and become perfect, which is to say ready for laying. This further treading must happen at precise moments in the egg's development, whereas in the case of fish eggs, Aristotle explains, "there is no such point fixed, but the males sprinkle them without delay to keep them in sound condition" (3.7.757b8-10).

Fish eggs, then, are fertilized prior to deposition, but they must be repeatedly fertilized after deposition as well, by the milt of the male, if they are to survive. Fishermen see male fish spreading milt, and presume that it is what fish do instead of copulation, whereas, for Aristotle, it is not a replacement for copulation, but rather a supplementation of it. It is far

[35] See Theo Tait, review of Eilperin, *Demon Fish*, 19.

more easy to observe external milt-spreading than copulation, since in most species of fish copulation is very rapid, so rapid as to escape the notice of the inattentive, and "of course," Aristotle observes with what seems a hint of contempt, "no fisherman ever watches this sort of thing for the sake of pure knowledge" (3.5.756a34-35).

A corollary to the widespread view that fish do not copulate is that they do not have male and female among them, but are all, strictly speaking, female. Aristotle cites the popular view according to which the analog of sexual difference in fish is the same as that in some species of plants, "in which one tree will bear fruit and another will bear none (e.g., the olive and oleaster, the fig and caprifig)" (3.5.755b8-12). It is not clear whether Aristotle thinks that those opponents who hold this view fail to notice that some fish spread milt, or if they in fact do notice this, just as the fishermen do, but take it to be something different from male semen. In any case Aristotle offers as a key piece of evidence for sexual difference in fish the fact that "semen can clearly be seen oozing out of males of both groups [selachian and non-selachian] at the proper season" (3.5.755b15-17).

As already indicated, the prolificness of fish provides another reason for Aristotle's opponents, in this case researchers rather than common fishermen. Aristotle cites the view according to which "none of the animals which copulate produces many young" (3.5.755b24-26). He agrees with this claim, but disputes the inference that this excludes fish from the class of copulators, even though they lay many eggs. Again, the eggs are imperfect and most of them are destroyed, and so their initial production does not count, Aristotle thinks, as the production of young. "Thus fish are male and female, and they copulate, all of them" (3.5 Aristotle concludes, while making a minor exception to this universal quantification for the *Erythrinus* (probably *Serranus anthius*, or sea-perch) and the *channa* (probably *Serranus scriba*, or the painted comber) (3.5.755b20-23), which Aristotle takes to be without a distinction between the sexes. He gives no explanation for their existence.

There is an age-old question to which Aristotle turns in the latter part of 3.5. and all of 3.6.: whether oral sex counts as copulation. At least with respect to reproduction, which is the only respect that matters for Aristotle, the answer is decidedly negative. Since Herodotus, whom Aristotle ridicules as 'the fable-teller' (ὁ μυθολόγος), the idea had circulated "that fish conceive by swallowing the milt" (3.5.756b7-8). Whatever goes into the stomach, though, undergoes concoction (ἡ πέψις), which Aristotle seems to describe here as a different process

than what occurs in the generation and development of eggs, while earlier in the GA Aristotle has repeatedly described this process as at work both within the egg (e.g., 3.2.753a17-19) and in the uterus (2.7.747a6-8). Whether concoction is limited to the stomach or not, Aristotle is certain that whatever is concocted in the stomach cannot pass to the uterus.

Aristotle goes on, in 3.6, to fault his adversaries, this time citing Anaxagoras by name, for making the same assumption about species of birds that are frequently seen making beak-to-beak contact: the raven, the pigeon; and, among quadrupeds, the weasel. Aristotle protests again that whatever passes into the mouth will be concocted by the stomach, and moreover there is no passage from the stomach to the uterus (3.6.756b27-29). In the case of the weasel Aristotle says that the fable arises from the fact that fissipede animals give birth to very small young, and tend to carry them around in their mouths: the weasel 'takes in' (δέχονται) its young, thus yielding another instance of the sort of postnatal care that Aristotle discusses in detail in relation to certain shark species in HA 6.10.

A final erroneous theory in 3.6. involves the hyena and the unidentified animal known as the *trochos*, evidently some sort of quadruped. There are those, Arisotle says, who hold that these animals are hermaphrodites, possessing two sets of pudenda. The *trochos* is able to fertilize itself, while the hyena alternates from year to year, now playing the male role and fertilizing others, now playing the female role and being fertilized. In the HA Aristotle has correctly identified what appears to be the vagina in a male hyena as, in fact, the anal gland (HA 579b25-30). And in the GA he repeats that "the hyena has been observed to possess one pudendum only; but hyenas have under the tail a line similar to the female pudendum" (3.6.757a8-10). While hyenas with penises invariably have this long vertical slit, they lack uteruses. Thus, this species exhibits the same sexual division we find in all quadrupeds.

Of the *trochos* nothing can be said, so it will perhaps be best now to move on to our conclusion.

4. Birds, Fish, and Reptiles in the Order of Generation

The bird's egg is perfected inside the female, which is to say that it is fertilised by the male before being laid. Fish eggs by contrast, mostly, are fertilised outside of the female, and for the same reason are imperfect when hatched. It is also this difference that explains why bird

eggs are already separated into white (the male principle) and yolk (the female principle) when laid, while fish eggs are of a single homogeneous consistency and color at the outset. In this respect bird and fish eggs are on a spectrum that includes, at its lower end, insect larvae, which are too imperfect to be considered eggs at all, but differ from fish eggs only by degree. In Book 2 Aristotle has already explained the difference between eggs and larvae as follows: "an egg is something from *part* of which the new creature is formed, while the remainder is nourishment for it; whereas in the case of the larva, the *whole* of it is used to form the whole of the offspring" (2.1.732a29-32). Now on a first glance it may appear that this distinction makes the larva superior to the egg: it is entirely analogous to the white of the egg, from which the bird is formed, while including nothing analogous to the yolk. But here we have in effect an equivalency between the larva and the wind-egg. In 3.9 Aristotle explains that larvae are in effect eggs that are deposited before their time, and that this is due to the relative imperfection of the nature of insects (3.9.758b19-22).

At the other end of the spectrum are the viviparous animals, whose relatively greater perfection lies in the fact that they come out of the mother not only already fertilized by the father, but indeed already having the form of the adult animal. Insects are extremely imperfect, by this measure: it has four stages in its life cycle (Aristotle seems not to have known that the insect lays proper eggs prior to the development of the larva, and took the larva as the first stage of development), and only the final one looks anything like the adult of the species. It was only in the early 18th century that Linnaeus would give the name of 'imago' to this final stage, but it is revealing and helpful for us to project back into Aristotle's scheme: that animal kind is more perfect, whose newborns are closer to the imago stage of the species, where 'imago' is understood not as image in the sense of reflection, but rather the ideal representation of the type. At the opposite extreme, as a non-existent limit case, we have the animal that would appear as a perfect copy of its parent, not only with respect to figure, but also with respect to dimensions. No animal can, of course, be as big as its mother --for how could its mother contain it?-- but if an animal could be, it would be most perfect indeed. "The more perfect and better of the animals," Aristotle had explained in GA 2, "produce their young in a perfect state so far as their quality is concerned (no animal brings forth young that are perfect in *size*, because they all grow in size after they have been produced)" (2.1.733b1-4). If an animal did not have to increase in size, if it were the same size as its parents all along, then it would follow that it could not be born *out of* its mother at all. This is in the end another way of saying that such a creature would be ungenerable, and thus eternal, which

would transport it out of the realm of the sublunar beings altogether, whose defining ontological parameter is that they are able to attain eternity only in kind, but not in number (2.1.731b32-732a2).

Throughout this chapter we have never strayed very far from Aristotle's belief that the perfection of an animal kind is reflected in its mode of generation: the more perfect the kind, the less becoming it has to do after it is born, and, therefore, the more the newborn of the species resembles the adult form. Today paleanthropology tells us that human parturition at nine months, while the newborn is still completely unable to fend for itself in the world, to eat and to walk around, is an evolutionary consequence of the fact that the cranium of our *Homo* ancestors expanded far more rapidly than the passage through the pubic bone of the mother could accommodate. Thus an evolutionary adaptation brought it about that all human beings, in effect, are born prematurely. The newborn's need for care, in turn, promotes sociality, which in turn promotes social intelligence and the evolution of still larger crania (and smaller teeth). When a newborn marine iguana (*Amblyrhynchus cristatus*) emerges from its shell, in the very first few seconds of life, it might find itself darting across the beach, away from the predator snakes that would coil around it and devour it, in order to find other members of its species higher in the rocks where the snakes cannot climb. The baby iguana is, obviously, a more perfect representative of its species, both morphologically and behaviorally, than a newborn human being.

In 3.2. Aristotle offers a largely impromptu digression on what we might call comparative ethology:

> It looks as though Nature herself desires to provide that there shall be a feeling of attention and care for the young offspring. In the inferior animals this feeling which she implants lasts only until the moment of birth; in others, until the offspring reaches its perfect development; and in those that have more intelligence, until its upbringing is completed. Those which are endowed with most intelligence show intimacy and attachment towards their offspring even after they have reached their perfect development (3.2.753a8-15).

Today we tend to see neural plasticity and ability to learn --in short, change-- as markers of superior intelligence (and thus, at least implicitly, of superiority *simpliciter*), rather than

perfection at the moment of birth. Aristotle for his part recognizes the connection between parenting and intelligence, and more broadly between sociality and intelligence, but does not seem to recognize that what it is that care brings about in developing animals is, precisely, change, development, improvement: which means, in turn, that the superior animals are farther away from their perfection, behaviorally at least, if not also morphologically, than the inferior ones. Whether or not this fact poses a problem for Aristotle's general account of generation, and his criteria for the establishment of degrees of perfection within this account, may be a topic for further research.