Whether Darwinian Evolution Is Possible

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The great problem which has so long exercised the minds of naturalists, namely, that concerning the origin of different kinds of animals and plants, seems at last to be fairly on the road to receive—perhaps at no very distant future—as satisfactory a solution as it can well have.

But the problem presents peculiar difficulties. The birth of a "species" has often been compared with that of an "individual." The origin, however, of even an individual animal or plant (that which determines an embryo to evolve itself —as, e.g., a spider rather than a beetle, a rose plant rather than a pear) is shrouded in obscurity. *A fortiori* must this be the case with the origin of a "species."

Moreover, the analogy between a "species" and an "individual" is a very incomplete one. The word "individual" denotes a concrete whole with a real, separate, and distinct existence. The word "species", on the other hand, denotes a peculiar congeries of characters, innate powers and qualities, and a certain nature realized indeed in individuals, but having no separate existence, except ideally as a thought in some mind.

Thus the birth of a "species" can only be compared metaphorically, and very imperfectly, with that of an "individual."

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> Individuals, as individuals, actually and directly produce and bring forth other individuals; but no "congeries of characters", no "common nature", as such, can directly bring forth another "common nature," because, per se, it has no existence (other than ideal) apart from the individuals in which it is manifested.
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> The problem then is, "By what combination of natural laws does a new 'common nature' appear upon the scene of realized existence?" i.e., how is an individual embodying such new characters produced?

So begins a work entitled *On the Genesis of Species* by St. George Mivart, published in 1871, just twelve years after Darwin published the first edition of the *Origin of Species*. The problem, as he states it, is "by what combination of natural laws does a new 'common nature' appear upon the scene of realized existence?" This is a striking and incisive introduction to a work examining Darwin's theory of how species might naturally come into being. "Naturally" here means by natural causes, for it certainly does not mean what happens always or for the most part, or what happens by an intrinsic, *per se* principle. Rather, for Darwin natural causality is opposed to Divine causality and not dependent upon it. This being the case, one must ask from what natural substances do new species come and what are the natural agents that bring the new species into existence? Regarding the former, there are only three possibilities: 1) all new species come from non-living substances, 2) all species come from living substances of another species, or 3) some species come from non-living and some from living. To explain the origin of *all* living things from natural causes, the third is the most reasonable option.

The focus of Darwin's argument, however, is to explain how a new species can come from another species of living thing, number 2 above. Here again there appears to be two options, either an individual of one species simply changes into an individual of another species or an individual of one species gives birth to an individual of another species. From

what naturalists at Darwin's time knew, both the generation of an animal from non-living material and the change of an individual from one species into another would involve spontaneous generation, which is contrary to careful observation, and would have the appearance of being more miraculous than natural. With good reason, then, Darwin opts for the notion that a new species is born from a previously existing species. If one were to object that this has not been observed in nature either, Darwin would respond by saying it does not happen all at once but very gradually; evolution has been happening all along but unnoticed. Because the generation of organisms is "shrouded in obscurity," we must grant that evolution through generation cannot be denied as though it were an obvious impossibility.

Now one difficulty with this position is precisely the one raised by St. George Mivart in the above quotation. Both Aristotle and Saint Thomas hold that parents do not generate species; they generate individuals of a given species. To put it another way, the parent generates the composite (the individual animal, body and soul) *per se* and the form or species *per accidens*, that is, only insofar as it has generated the composite. Moreover, Aristotle holds that the forms of natural substances are neither generable nor corruptible *per se*.

The evolutionist might respond that if a parent can generate an individual of its own species why can't it generate an individual of a new species when influences in the environment somehow change the generative power of the organism. This possibility has not been excluded, but an understanding of these exceptional cases would certainly presuppose an understanding of what normally happens in animal generation.

The first question, then, is how a common nature is passed on from parent to offspring in the generation of an individual of a given species. Unlike the evolution of species, the generation of organisms takes place before our very eyes. Yet the means by which the life, or the soul, or the specific form gets passed from parent to offspring is not obvious. We know

that it indeed happens, but how? I would like to look first to the account of Aristotle and Saint Thomas and then consider what modern biologists have discovered about the generation of organisms. For we cannot rightly judge how species might evolve without knowing how they are naturally propagated.

Let's begin by distinguishing different senses of the term 'generation'. In the Treatise on the Trinity in the *Summa Theologiae*, Q. 27, art. 2, Saint Thomas states the following:

> . . . 'generation' has a twofold meaning: one common to everything subject to generation and corruption; in which sense generation is nothing but a change from non-existence [non esse] to existence [esse]. In another sense it is proper and belongs to living things, in which sense it signifies the origin of a living being from a conjoined living principle; and this is properly called birth. Not everything of that kind, however, is called begotten; but, strictly speaking, only what proceeds by way of similitude. . . . Nor will any likeness suffice; for a worm which is generated from animals has not the aspect of generation or sonship, although it has a generic similitude; for this kind of generation requires that there should be a procession by way of similitude in the same specific nature. . . . So in living things, which proceed from potential to actual life, such as men and animals, generation includes both these kinds of generation.

Generation, then, has a general sense that is applicable to the living and non-living alike insofar as we are speaking about the coming-to-be of a new substance and the corruption of a previous one. The meaning of generation proper to living things involves the further notion of birth or being begotten from a conjoined living principle. In the strictest sense, what is generated must be the same in species as the generator. However, the origin of species, according to the Darwinian Theory, would involve generation in a sense proper to the living, but not the strictest sense. For at some point in the process what is generated would not have a specific likeness to the generator, however gradually this might happen. After

examining how the nature or species is passed from parent to offspring in the ordinary course of animal generation, the question will be whether a living thing can generate, by its own natural generative powers, an individual of a different species.

The Aristotelian Theory of Animal Generation

Introduction

Aristotle begins his treatise on the *Generation of Animals* by summarizing what he has done in his treatise on the *Parts of Animals* and then stating the following:

> It remains to speak of those parts which contribute to the generation of animals and of which nothing definite has yet been said, and to explain what is the moving cause. To inquire into this last and to inquire into generation of each animal is in a way the same thing; and, therefore, my plan has united them together, arranging the discussion of these parts last, and the beginning of the question of generation next to them.
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> Now some animals come into being from the union of male and female, i.e., all those kinds of animal which possess the two sexes. This is not the case with all of them; though in the sanguinea with few exceptions the creature, when its growth is complete, is either male or female, and though some bloodless animals have sexes so that they generate offspring of the same kind, yet other bloodless animals generate indeed, but not offspring of the same kind; such are all that come into being not from a union of the sexes, but from decaying earth and excrements. . . . Of these, all which are produced by union of animals of the same kind generate also after their kind, but all which are not produced by animals, but from decaying matter, generate indeed, but produce another kind, and the offspring is neither male nor female; such are some of the insects. This is what might

> have been expected; for if those animals which are not produced by parents had themselves united and produced others, then their parents ought to have come in being in the same way; this is only a reasonable postulate to make, for it is plainly the case with other animals. If unlike, and yet able to copulate, then there would have come into being again from them another kind of creature and again another from these, and this would have gone on to infinity. But nature flies from infinity; for the infinite is imperfect, and nature always seeks an end. (I, 1, 715a18–715b15)

He ends the first chapter with this comparison to plants:

> . . . The same holds good also in plants, some coming into being from seed and others, as it were, by the spontaneous action of nature, arising either from decomposition of the earth or of some parts in other plants; for some are not formed by themselves separately but are produced upon other trees, as the mistletoe. . . .

These texts are interesting in many respects. First, it is clear that Aristotle believes that some organisms come to be spontaneously from decaying matter or excrement. Notice that he does not say that latter types of matter generate living things. He seems to be reserving that term for the sense in which the living generates another living thing from an active intrinsic principle. Secondly, he thinks that organisms which come to be from decaying matter are sometimes capable of sexual reproduction, but they do not produce organisms of the same kind nor are these offspring capable of sexual reproduction. Yet he does call this generation, for there is at least a generic similitude between parent and offspring. Thirdly, more perfect types of animals have the more perfect mode of generation; they come to be by sexual reproduction from parents of the same species, are themselves either male or female, and generate offspring of the same species by sexual union. The remainder of his treatise focuses primarily on this type of generation.

Now, an advocate of the theory of evolution would find Aristotle's belief in spontaneous generation an extremely generous postulate for evolutionary theory. Aristotle thinks that spontaneous generation of the living from the non-living happens all the time. Modern evolutionists, on the other hand, hold that it happened only once or maybe a few times millions of years ago. Moreover, Aristotle grants that in some cases one species produces individuals of another species by sexual reproduction. This, again, is an extremely generous concession that makes Aristotle's view quite compatible with modern theories of evolution.

I might point out that Aristotle's opinion on these matters comes from, 1) what seemed apparent to the senses (spontaneous generation), 2) his view about the fineness of the gradation of being, and 3) his view on the role that equivocal agents, such as the sun, play in the generation of organisms. The sun was thought to prepossess the forms of living things in a preeminent mode and to be a primary efficient cause of animal generation.

Aristotle's Account of Generation

Focusing on animal generation in the strictest sense, Aristotle begins by pointing out that the male and female principles are the foremost principles of generation, the male as containing the efficient cause of generation and the female the matter of it. He says:

> The most convincing proof of this is drawn from considering how and whence comes the semen; for it is out of this that those creatures are formed which are produced in the ordinary course of nature; but we must observe carefully the way in which semen actually comes into being from the male and female. For it is just because the semen is secreted from the two sexes, the secretion taking place *in* them and *from* them, that they are first principle of generation. For by a male animal we mean that which generates in another, and by female that which generates in itself. . . . (716a7–15)

As usual the Philosopher knows exactly where to begin an investigation. Moreover, considerations of how the semen is produced and its mode of causality determine one's account of animal generation. It is precisely on these points that Aristotle and modern biologists disagree.

Notice that Aristotle uses the term semen generally for what is produced by both male and female. When he takes up the question of the nature of semen he says:

> . . . Everything which we find in the body must either be one of the natural parts, whether homogenous or heterogeneous, or an unnatural part such as a growth, or a residue or waste-product, or nutriment. (By residue I mean what is left of the nutriment, by waste-product that which is given off from the growth by an unnatural decomposition.) 724b21–28

He concludes this discussion by saying that semen is not a part of the body but "a residue of useful nutriment, and that in its last stage . . ." (726a26) and further, "semen will be a residue of nutriment when reduced to blood, being what is finally distributed to the parts of the body." (726b10) In regard to the female he says "that the sanguineous matter discharged by the female is also a residue. And such is the discharge of the so-called menstrual fluid." (727a1) The difference between the semen of the male and menstrual fluid is that the woman is incapable of concocting the nutriment in its last stage into semen like that of the male owing to the coldness of her nature. Menstrual blood is semen in a non-pure state in need of working up. (728a16–26)

Aristotle's argument that semen cannot be a part of the body "is plain," he says, "for it is homogeneous, but from it nothing is composed, as things are from sinew and flesh; nor is it separated as are all the other parts." (724b30). By "nor is it separated" he means that semen is not like any of the organs which are separate and distinct parts, the heart, for example, or the lungs.

The position Aristotle takes here is one of the principles that determines everything he holds about animal generation. It is precisely on this point that moderns have discovered things to be otherwise.

What roles do the respective secretions of the male and female play in generation? Aristotle's takes as a general principle that

> . . . what the male contributes in generation is the form and the efficient cause, while the female contributes the matter. In fact, as in the coagulation of milk, the milk being the material, the fig-juice or rennet is that which contains the curdling principle, so acts the secretion of the male. . . . (729a9)

Aristotle then asks more particular questions: how does the male contribute to generation and how is the semen from the male the cause of the offspring? Does the semen exist in the body of the embryo as a part of it from the first, mingling with the material which comes from the female, or does the semen communicate nothing to the body of the embryo but only to the power and movement in it? He answers by saying that the latter alternative appears to be the correct view both *a priori* and in view of the facts. His *a priori* argument is as follows:

> For, if we consider the question on general grounds, we find that, whenever one thing is made from two of which one is active and the other passive, the active agent does not exist in that which made; and, still more generally, the same applies when one thing moves and another is moved. But the female, as female, is passive, and the male, as male, is active, and the principle of the movement comes from him. Therefore, if we take the highest genera under which they each fall, the one being active and motive and the other passive and moved, that one thing which is produced comes from them only in the sense in which a bed comes into being from the carpenter and the wood, or in which a ball comes into being from the wax and the form. It is plain

> then that it is not necessary that anything at all should come away from the male, and if anything does come away it does not follow that this gives rise to the embryo as being in the embryo, but only as that which imparts motion and as the form; so the medical art cures the patient.

So, this argument follows simply from his definition of male and female and from the relation between the mover and moved as discussed in Book III, Chapter 3 of the *Physics*. However, Aristotle does not think his *a priori* argument is sufficient in itself. He can conclude only that it is not necessary that the male contribute anything materially to the offspring. One must look to what actually happens in nature.

The facts he presents have to do with the breeding of insects, birds, and fish in none of which does the semen of the male appear to contribute anything materially to the eggs but only a quality; there seems to be no change in the size of the eggs, which is what one would expect if the males contributed something materially to the embryo (I, 21). Therefore, he concludes the semen of the male is agent only and that of the female is matter only.

In Book II Aristotle takes up the following question:

> . . . whether the soul "in virtue of which an animal is so called (and this is in virtue of the sensitive part of the soul) —does this exist originally in the semen and in the embryo or not, and if it does whence does it come from? For nobody would put down the embryo as soulless or in every sense bereft of life, and it is productive up to a certain point. That then they possess the nutritive soul is plain (and plain is it from the discussions elsewhere about soul why this soul must be acquired first). As they develop they also acquire the sensitive soul in virtue of which an animal is an animal. . . . For example, an animal does not become at the same time an animal and a man or a horse or any other particular animal. For the end is developed last, and the peculiar character of the species is the end of the generation in each individual. (736a24–736b9)

Notice how Aristotle takes together the question whether the semen has soul with the question of succession of souls in a developing organism. Further, he says it is clear that "the semen and embryo, while not yet separate, must be assumed to have the nutritive soul potentially, but not in actuality, until (like those embryos that are separated from the mother) it absorbs nourishment and performs the function of the nutritive soul. For at first all such embryos seem to live the life of a plant." (736b10)

Aristotle further says that even the emitted semen lacks a soul, yet it has *vital heat* by which it is productive of life. Vital heat is not fire, nor any such force,

> . . . but it is the breath included in the semen and foam-like, and the natural principle in the breath, being analogous to the element of the stars. Hence, whereas fire generates no animal and we do not find any living thing forming in either solids or liquids under the influence of fire, the heat of the sun and that of animals does generate them. Not only is this true of the heat that works through the semen, but whatever other residue of the animal nature there may be, this also has still a vital principle in it. From such considerations it is clear that the heat in animals neither is fire nor derives its origins from fire. (736b32–737a7)

It is this vital heat which is given to the semen by the male and in virtue of which the semen acts instrumentally impressing this vital heat into the menstrual fluid causing the nutritive powers to come to be in it. Once possessed of the power to nourish itself, an organism has been formed in the menstrual fluid having a vegetative soul.

In summarizing Aristotle's account of animal generation in the *Summa Contra Gentiles* (II, 89), Saint Thomas says,

> And yet it cannot be said that the soul, as to its complete essence, is in the semen from the very beginning, and that the operations of the soul are not apparent on account of the lack of organs. For, since the soul is united to the body as its form, it is not united to a body other than the one of which

it is properly the act. Now *the soul is the act of an organic body*. Consequently the soul is not actually in the semen before the organization of the body, but only potentially or virtually.

Further, in the same chapter, he continues:

> Therefore, the selfsame virtue which is severed together with the semen and is called the formative virtue, is not the soul, nor does it become the soul in the process of generation: but, since it is based, as on its proper subject, on the (vital) spirit contained in the frothy semen, it causes the formation of the body insofar as it operates by virtue of the father's soul, to whom generation is ascribed as the principal agent, and not by virtue of the soul of the person conceived, even after the soul is in that person: for the subject conceived does not generate itself, but is generated by the father.

Beginning with the last sentence, the continuation of this text provides an argument for the succession of souls:

> This is clear to anyone who considers each power of the soul separately. For it cannot be ascribed to the soul of the embryo by reason of the generative power: not only because the generative power does not exercise its operation until the work is completed of the nutritive and augmentative powers which are its auxiliaries, since to generate belongs to that which is perfect; but also because the work of the generative power is directed, not to the perfection of the individual, but to the preservation of the species. Nor again can it be ascribed to the nutritive power, the work of which is to assimilate nourishment to the subject nourished, which is not apparent here; since in the process of formation the nourishment is not assimilated to something already existing, but is advanced to a more perfect form and more approaching to a likeness to the father. Likewise neither can it be ascribed to the augmentative power: since it belongs to this power to cause a change, not of form, but of quantity. As to the sensitive and intellective part, it is clear that it has no operation appropriate to such a formation. It remains

> then that the formation of the body, especially as regards the foremost and principal parts, is not from the form of the subject generated, nor from a formative power acting by virtue of that form, but from a formative power acting by virtue of the generative soul of the father, the work of which soul is to produce the specific like of the generator.
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> Accordingly this formative power remains the same in the aforesaid spirit from the beginning of the formation until the end. Yet the species of the subject formed remains not the same: because at first it has the form of semen, afterwards of blood, and so onwards until it arrives at its final complement. For although the generation of simple bodies does not proceed in order, since each of them has an immediate form of primary matter; in the generation of other bodies, there must be an order in the generations, by reason of the many intermediate forms between the first elemental form and the final term of generation: wherefore there are a number of generations and corruptions following one another.

So neither does the semen possess a soul actually nor does the conceptus possess the active power to produce its own parts. The semen must remain in contact with the embryo and cause the formation of it from beginning to the end. This position is even more clear in the *Summa Theologiae* (I, 118, 1 ad 4):

> This matter [the fetal matter in the female] therefore is transmuted by the power which is in the semen of the male, until it is actually informed by the sensitive soul. . . . And after the sensitive soul, by the power of the active principle in the semen, has been produced in one of the principal parts of the thing generated, then it is that the sensitive soul of the offspring begins to work towards the perfection of its own body, by nourishment and growth. As to the active power which was in the semen, it ceases to exist when the semen is dissolved and the (vital spirit) thereof vanishes.

If I understand Aristotle and Saint Thomas correctly, the newly conceived organism does not have a principle within it

to bring its own parts into being. There must be an extrinsic cause, the semen, which brings the parts into existence. Saint Thomas gives further arguments for this in the above-cited chapter of the *SCG*:

> For according to this opinion [that there is an intrinsic principle in the organism to bring the parts into existence] it would follow that the same identical virtue is at one time a purely vegetative soul, and afterwards a sensitive soul: so that the substantial form would be perfected more and more by stages. It would also follow that the substantial form would be brought from potentiality to act not at once but by degrees. And again, that generation, like alteration, is a continuous movement. All of which are impossible.

Galen, on the other hand, includes the faculty of genesis as one of the faculties of the vegetative soul. And by genesis Galen means the coming to be of the parts, which takes place by alteration and shaping. So Galen clearly thinks that animals have an intrinsic principle for generating their own parts in embryologic development.

Let us summarize Aristotle's account of the generation of perfect animals where like produces an individual with the same specific likeness by sexual reproduction. Male is defined as that which generates in another and the female that which generates in itself. The semen of the male and female are both homogenous residues of nutriment and never have been a natural part of the living body. The semen of the male differs from that of the female by being more highly concocted nutriment due to the superiority of the male to the female. The semen is an instrumental agent cause not possessed of a soul itself but having vital spirit from the male in virtue of which it is able to act on (curdling, as it were) the menstrual fluid of the female and bringing into existence a living embryo. The semen is agent only and contributes no matter to the body of the embryo and the menstrual blood contains no part that is the body of the embryo before fertilization. Hence, there is the generation of the living from the non-living. Furthermore, the semen continues to act on the embryo until the succession of souls to the sensitive stage is complete.

This account is not only contrary to what is now observable but it has always had certain awkward consequences. The notion of succession of souls seems contrary to our sense of the unity of the development of an individual organism. Furthermore, the means by which the semen of the male can continue to cause the succession of souls without being in contact with him and without itself possessing the souls seems problematical. Let us see whether the modern account can solve some of these difficulties.

The Modern Account

Introduction

Aristotle begins the second book of the *Parts of Animals* by pointing out three degrees of composition in animals. First is composition out of the elements: earth, air, fire and water. The second degree is that by which the homogenous parts are constituted out of the elements, for example, bone, flesh, and nerve, etc. The third and last stage is the composition that forms the heterogeneous parts, such as the face, hands, and the rest. This division seemed complete until recent times. Ancients such as Galen thought that the nutritive powers of attraction, retention, alteration, and expulsion all belong to each of the homogenous parts of the body. So, by the power of attraction the kidney would attract and assimilate what was proper to it, and this would be different than what the liver would attract and assimilate to itself. Considered as a general division of the kinds of composition in an organism, perhaps this is complete. Yet biologists discovered in the mid-nineteenth century that the homogenous parts have a smallest part, the so-called cell. Theodore Schwann, the first to notice similarities between the plant cell and the smallest parts

of animal tissue, saw analogous structures in each. He theorized that all cells came to be by the same processes, which involved only chemical and physical laws. A particle, the nucleus, would draw to itself other chemicals from extra-cellular fluid and form a membrane around itself. This is not unlike modern theories of molecular evolution whereby a cell might come to be simply by the natural ability of the elements to attract and arrange themselves into molecular and crystalline structures.

Cell theory was advanced by Virchow's discovery of cell division in the growing root tips of plants. He theorized that cells do not arise in the manner proposed by Schwann; rather *all* cells come to be from cells by division. This theory seems to be borne out by observations since his time and has been established as Virchow's Law, *Omnis cellula e cellula.*

Both Schwann and Virchow immediately conceived the cell to be the unit of life. And just as the chemists who discovered that there are units of chemical composition, Schwann and Virchow made analogous claims about the relation of the cells to the whole organism. Schwann argued that there are no powers belonging to the whole that are not found in the cells. The whole is nothing more than the sum of its parts. Virchow put it another way: the whole organism, a "so-called individual", as he put it, is nothing more than a social arrangement of vital unities. So, just as the atomists claim that the atoms are the only real individual substances, cell theorists make similar claims about cells being the only real living things.

Perhaps this mistake made by the cell theorist is more contrary to ordinary experience than that made by the chemists. It seems more obvious that a human being or a dog is one organism than methyl alcohol is one substance. To complicate matters further, some cells, for example, skin cells, can be removed from the body and kept alive and even reproduced if provided with the right conditions. This seems to support the view that every cell is an independent vitality. On the other hand, to maintain that a human being is one organism we

must argue that the trillions of cells that make up the human body all participate in one life as a part of a whole. It is evident to biologists that cells which are part of a human being act differently than those grown in a Petri dish. A skin cell put in a Petri dish acts as a unicellular organism and moves from place to place. When part of an organism, the cells act for the sake of the whole. Cancer cells are well-known exception to this, and they cause problems primarily because their growth and reproduction are no longer subject to the control of the organism.

Why am I pursuing this point? It manifests something Aristotle points out in his treatise on the soul. (*De Anima* I, 5, 411b26–27; II, 2, 413b17–25) He asks whether the whole soul is in all of the parts of the organism. He answers that it must be, otherwise it would not be possible to cut a worm in half and have both parts live as separate organisms of the same species. Saint Thomas gives a further reason:

> . . . if it (the soul) were the form of the whole and not of its parts, it would not be the substantial form of that body: thus, the form of the house, which is the form of the whole and not of each part, is merely an accidental form. That it is the substantial form of both the whole and of the parts is clear from the fact that both the whole and its parts take its species from it. Wherefore, when it departs, neither the whole nor the parts retain the same species: for the eye or flesh of a dead person are only so equivocally. . . . This applies to the whole soul . . . insofar as it is a form. (*SCG* II, 77)

A skin cell crawling in a Petri dish, strictly speaking, is not skin anymore. The general point made here will be important later when we speak of the modes of reproduction.

There is another analogy between atoms and cells. Most if not all chemical activity of substances takes place at the level of atom acting on atom, so with the nutritive powers of the soul. It is at the level of the cell that the assimilation of nutriment takes place. Furthermore, the growth of the whole or-

ganism is the result of the growth and multiplication of cells. The alterative and shaping powers of the faculty of genesis mentioned by Galen in fact take place at the cellular level by differentiation and addition of cells in fixed directions. Finally, the generation of organisms, as we will see, involves the production, multiplication, and differentiation of cells. This may be a reason beyond the argument from final cause that Aristotle gives (*De Anima* II, 4) for the generative power belonging to the nutritive soul. All these powers have in common that their activities take place at the level of the cell.

Modes of Animal Generation

Modern biologists no longer believe organisms are naturally or normally produced by spontaneous generation out of non-living material. Nor do they believe that one species spontaneously generates another species in the normal course of generation. They rely on spontaneous generation in both of these senses only as a god-of-the-gaps explanation for the origin of living things from the non-living or of a new species from an existing species; neither has been observed. Therefore, it appears that all organisms are naturally generated either asexually or by the union of sexes.

Asexual Reproduction

Let us begin with asexual reproduction. There are several modes of asexual reproduction, the simplest form of which is the generation of a unicellular organism by simple cell division. When such an organism reaches maturity, it replicates its parts and then splits into two equal cells half the size of the original cell but in full possession of all its organelles. Because of the equality of these cells, biologists call them both daughter cells. There is no mother that remains. This case is like Aristotle's severed worm example; neither part is called mother even though the two are not as alike as the

two daughter cells. For one worm needs to generate a new mouth and the other a new rear-end! (Which would you call "mother"?) Both Aristotle and Saint Thomas hold that in the case of the worm before division there is one soul that is potentially many. When the division takes place that which was potentially two becomes actually two. Here there is no generation of the living from the non-living, rather there is simply the division of the living into two by the division of its quantity. The same must be true of the generation of unicellular organisms. The main difference is that cell division is a natural process caused by principles within the cell while the worm is divided by violence.

Multi-cellular organisms reproduce asexually by producing either a multi-cellular part that is separable or a unicellular part. An example of the former is budding in plants and lower forms of animals such as hydra. In this case the parent organism produces a part which at first participates in the life of the parent organism. At some point the budding part separates and survives on its own. Many plants send up suckers from their roots. After some time these suckers grow more roots and are able to be separated from the mother plant. Again, there is no generation of the living from the non-living here. There is simply a severance of a living thing from a living thing of the same species.

If a multi-cellular organism produces a unicellular part that develops into a whole organism, the part is usually called an ovum. There are many animals that produce ova capable of producing offspring parthenogenetically, i.e., without being fertilized. Aphids produce winged offspring when they reproduce sexually and wingless ones when they reproduce asexually. In many insects the sex of an individual is determined by whether or not it comes from a fertilized egg. Worker bees, which are all females, are produced from fertile eggs and drones from unfertilized eggs. There are several species of reptiles and even birds that can reproduce parthenogenetically.

What do we say about the ovum that does not need to be fertilized in order to develop into a normal individual of the mother species? When joined to the mother as a part, the ovum participates in the life of the mother and therefore has the soul of the mother in it. It is also distinguished from other cells of the body that might be separable, because, unlike the above-mentioned skin cells, the ovum has the potency to become a whole organism of the same species as the mother and is ordered to this end by nature. It seems reasonable to say that when separated from the mother the ovum is an imperfect individual of the same species. According to the modern view, it has all the organelles necessary for nutrition, growth, and production of its own parts without the action of an external agent. But insofar as it lacks those parts it is imperfect when separated.

What would Saint Thomas and Aristotle think of this account of animal generation? Let us go back to the text from the *SCG* (II, 89):

> And yet it cannot be said that the soul, as to its complete essence, is in the semen from the very beginning, and that the operations of the soul are not apparent on account of the lack of organs. For, since the soul is united to the body as its form, it is not united to a body other than one of which it is properly the act. Now *the soul is the act of an organic body*. Consequently the soul is not actually in the semen before the organization of the body, but only potentially or virtually. It would also follow, if the soul were in the semen from the beginning, that the generation of an animal would be by the mere severance, as happens in annulose animals, where two are made from one. For if the semen were animated as soon as severed, it would at once have a substantial form.

Another text taken from the *De Potentia* adds to this argument:

> If the soul were in the semen from the beginning . . . it would follow moreover that the generation of a living being would not be generation but a kind of separation, just as timber cut from timber is actually timber. (I, 3, 12, Body)

If Aristotle and Saint Thomas knew that in the female there is an organized body, the ovum, that is severed from a living, natural part of the mother, I believe they would concede everything Saint Thomas said would follow.

The text from the *SCG* continues:

> Now every substantial generation precedes, and does not follow, the substantial form; and if any changes follow the substantial form, they are directed, not to the being but to the well-being of the thing generated. Accordingly the generation of the animal would be completed in the mere severance of the semen: and all subsequent changes would have nothing to do with generation.

Hence, according to Saint Thomas, if the ovum is produced by mere severance from the female, it will have the same substantial form as the mother and there will be no need for a succession of souls. All subsequent changes will be ordered to the well-being of the thing generated. These subsequent changes would include the production, growth, and development of its parts. This is the position that ought to be maintained where organisms are produced asexually.

Sexual Reproduction

As in the female, the semen of the male also possesses cells severed from the living parts of his body. These sperm cells are alive and mobile. The successful sperm cell penetrates the ovum of the female and contributes genetic material to the ovum, or, at this point, the zygote. The sperm cell also initiates the process of development by stimulating cell division. So the sperm cell is both a material cause and an agent cause of the embryo, according to the modern account. It is less clear what to say about the nature of an ovum that depends on sperm for development than the ones that do not, and it

is even less clear what to say about the sperm cell because it does not have the potency to be a whole organism. The sperm cell, or at least its genetic material, seems to be ordered to being a permanent part of a new individual.

As mentioned above, many animals that reproduce parthenogenetically also reproduce sexually; bees were given as an example. The ovum of the bee clearly does not depend on the agency of the sperm for development to take place. The addition of the sperm helps determine the sex of the offspring. Hence the sperm cannot be seen as giving the soul to the ovum as in the ancient account.

Nor is it reasonable to say that an ovum that does depend on union with a sperm cell is essentially different from other ova. The mode by which the sperm stimulates development appears to be by removal of an impediment. It is known that as soon as the sperm enters the ovum, calcium ions, each carrying a positive charge, are quickly imported into the ovum. This changes the charge on its surface from negative to positive, creating an electrostatic field that prevents other sperm from entering the ovum. This change of charge also stimulates a sequence of cell divisions without the use of the sperm's DNA. In some cases development can be artificially induced simply by changing the polarity of the membrane of the ovum. For example, sea urchin eggs naturally require fertilization in order for development to proceed. However, simply pouring a mild solution of potassium chloride into a test tube containing eggs causes development. Scientists believe that the human ovum has all the equipment necessary "to carry out all the work and the guidance needed for the first several rounds of cell division with no help from the sperm." (Rensberger, p. 150) From then on the genetic material contributed by the sperm seems essential for normal development. Hence, although the sperm is in some way the agent cause of the beginning of development of the embryo it more importantly becomes a part or an organ of the embryo determining its individuality, growth, and development. In view of these facts we can not

say that the sperm is the instrumental cause of ensoulment of the embryo.

We might make an analogy with the relation of the mutual dependence of ovum to the sperm and that of the male to the female. Aristotle says:

> In all this nature acts like an intelligent workman. For to the essence of plants belongs no other function or business than the production of seed; since, then, this is brought about by the union of male and female, nature has mixed these and set them together in plants, so that the two sexes are not divided in them. . . . But the function of animals is not only to generate (which is common to all living things), but they all of them participate also in a kind of knowledge, some more and some less, and some very little indeed. (*GA* 731a25–32)

So in those animals which have the sexes separate ". . . when there is need for them to generate the sexes are no longer separated any more than in plants, their nature desiring that they shall become one; and this is plain to view when they copulate and are united [that one animal is made out of both]." (*GA* 731a10–13) Therefore, because the more perfect animals are ordered to a higher end than reproduction, they may be less perfectly equipped for reproduction and are in need of a helpmate. And in the case of man and many of the higher animals a helpmate is necessary not only for the generation of the offspring but also for its care until it is self-sufficient. Hence the sperm and ovum themselves are also imperfect requiring both for the production of the offspring.

We might also put it this way, plants are determined by their nature to reproduce as soon as they are mature and the external conditions are appropriate. For man, on the other hand, planned parenthood is an option.[1]

[1] It is interesting to note that modern biologists say that the purpose of sexual reproduction is to produce greater variation between individuals of a species so that there is more material for natural selection to work on

According to the modern account then, the generation of organisms does not include the notion of generation in the most general sense, i.e., the coming to be of a new kind of substance. All generation in the sense proper to the living involves the separation of a part that participates in the life and therefore, the species of the parent. Generation simply involves the production of a new individual analogous to separating timber from timber. In other words, life does not begin at conception, a new individual life does.

It is important to point out here that that this is not an adequate account of human generation. Both Aristotle and Saint Thomas argue that the human soul cannot be passed from parent to offspring by natural means. Saint Thomas also claims that it is the explicit teaching of the Church that each individual human soul has to be specially created by God. (*De Ecclesiasticis Dogmatibus*, xiv)

With better equipment for making observations we now know that there is no spontaneous generation of organisms. The dictum "like generates like" is in fact universal to living things. Thus, contrary to the ancient view, it appears that the only way non-living matter becomes living is by being consumed and assimilated or incorporated into a living organism. (This is a wonderful parallel to the way in which the intellectual creatures participate in the Divine Life by incorporation into the Mystical Body of Christ.)

What bearing does this account have on the genesis of species? We have attempted to answer the question where the soul and hence the species, comes from in the ordinary course of generation. The species comes from a participation in that

and a greater likelihood of adaptation to the environment. Although this may be true, Aristotle is pointing out that the more perfectly a species is ordered to knowing, the more important and, hence, distinctive the individual is as such. This seems to be true if we consider the gradation of knowing beings. There is more variation between individual men than there is between members of other species of animals, and the distinction between individual angels is a difference in kind.

of the parent. Generation simply involves a procession forth from the parent of a part that participated in its essence and was subsequently individuated by separation. This part, whether unicellular or multicellular, is distinguished from other parts of the organism by having the potency to be a whole organism. How can you get a new species out of this process?

The Modern Evolutionary Theory

Neo-Darwinists have answered this question by pointing to the principle of heredity, genes. They would agree that normally like generates like. As long as nothing happens to change the genes in the sperm or ovum, the offspring will look like its parents and be recognized as the same species. But genes are subject to mutation both in the natural course of transcription and by exterior agents such as ultraviolet radiation from the sun. Ninety-nine percent of the time significant mutations will be deleterious to the organism. However, the mutations that are not may give the organism a selective advantage. If over time there is a great enough accumulation of these mutated genes in a population of organisms, and the population is isolated well enough from other organisms of the same species, eventually there will be a change in species.

This argument, of course, assumes that the genes determine the species of an organism. As Franklin Harold puts it:

> For the majority of scientists today DNA is the very essence of life; the god in the biological machine. Textbooks wax ecstatic over the master molecule that holds all the instructions required to make and run an organism. A quarter of a century ago, Francois Jacob celebrated that nucleic acid message, which records 'the whole plan of growth, the whole series of operations to be carried out, the order and the site of synthesis and their coordination. . . .' Today, Richard Dawkins' influential writings make the richest mine of evocative and provocative imagery. 'Genes build bodies' to serve as their 'vehicles' and 'survival machines'; bodies are 'robots,' programmed by their DNA. . . . (pp. 67–69)

This view of genes, which was not based on knowledge but rather on hope and unrestrained imagination, is being undermined by modern research. The fields of cell and molecular biology have been centers of focus for biological research for the last fifty years and the discoveries made in them have been astounding. Evolutionists have complained that these discoveries are wreaking havoc on the neo-Darwinian synthesis. The cell, even those of the simplest unicellular organisms such as bacteria, is much more complicated than cell theorists had hoped. They are not simple blobs of protoplasm barely different than a mixture of inorganic molecules surrounded by a membrane. Their organization and structure is now compared to that of a highly industrialized city. The bacterium, *Escherichia coli*, is one of the most intensely studied microorganisms. It is 2 micrometers long and 0.8 in diameter. A compendium on *E. coli* and a close relative, *Salmonella*, was published in 1996 containing 2,800 double-column pages and more than 20,000 references. Still, only half of the gene sequencing has been done. The accumulating knowledge does not make the transition from a 'hot soup' to a living cell easier to imagine.

Furthermore, the same powers found in whole, complex organisms that were to be ultimately explained by the cell—sensation, locomotion, growth, nutrition, and reproduction—are all found in unicellular organisms with less apparent organs to explain them.

The aim of the molecular biologist is to explain these powers by chemistry. However, Harold points out that,

> Biochemists insist, rightly, that when one takes cells apart one finds nothing but molecules: no forces unique to life, no cosmic plan, only molecules whose writhings and couplings underlie and explain all that the cell does. . . . I share the commitment to a material conception of life, but that makes it doubly necessary to remember that before the cells were taken apart—as long, indeed, as they were alive—they displayed capacities that go beyond chemistry. Homeostasis,

> purposeful behavior, reproduction are not part of the vocabulary of chemistry but point to higher levels of order. (p. 65)

When speaking about the common characteristics of organisms that distinguish them from the non-living Harold points to organization:

> Whenever we speak of organisms we acknowledge the fundamental connection between the living state and a special kind of order. Even the simplest unicellular creatures display levels of regularity and complexity that exceeds by orders of magnitude anything found in the mineral realm. A bacterial cell consists of more than three hundred million molecules (not counting water), several thousand different kinds of molecules, and requires some 2,000 genes for its specification. There is nothing random about this assemblage, which reproduces itself with constant composition and for generation after generation. A cell constitutes a unitary whole, a unit of life, in another and deeper sense: like the legs and leaves of higher organisms, its molecular constituents have functions. Whether they function individually, as most enzymes do, or as component parts of a larger subassembly such as ribosomes, molecules are parts of an integrated system, and in that capacity can be said to serve the activities of the cell as a whole. . . . Organization, John von Neumann once said, has purpose; order does not. Living things have at least one purpose, to perpetuate their own species. Therefore, organization is the word that sums up the essence of biological order. (pp. 10–11)

It appears that the facts are moving careful observers, such as Harold, to question the "genocentric" theory of organisms and leading them in another direction. Harold says,

> The genetic program has rightly been the focus of intense scientific scrutiny and of public celebration, but adulation has got out of hand. The fallacy is the tacit assumption, taken as an article of faith, that all the levels of biological order are spelled out in the genome. That is obviously not

true for *E. coli*, and *a fortiori* not for more elaborate cells and organisms. . . .

One of the major points Harold makes in his book is that Virchow's law, *Omnis cellula e cellula*, must now be understood as "it takes a cell to make a cell," the title of one of his chapters. Harold speaks as though this is just a reformulation of Virchow's Law; on the contrary, it is really giving a reason for it. He says,

> Even those for whom life is simply the expression of the instructions encoded in the genes acknowledge that it takes cellular machinery to implement those instructions: enzymes, RNAs, energy, precursors, even the proper pH and ionic composition. But this can hardly be the whole story, for it fails to capture one of the key features of biological reproduction. Growth and division refer not simply to the accretion of biomolecules, but to the replication of an integrated pattern of functions and structures. These higher levels of order commonly depend upon molecular processes that have a particular direction or location in space. Reproduction is ultimately the business of cells, not of molecules, because direction and location are not spelled out in the genes; instead, a growing cell models itself upon itself. Michael Katz has a word for it; the cell serves as the *templet* (not template), a source of configurational information, for the construction of its daughters. (pp. 99–100)

This is true not only of cellular reproduction. It may likewise be said that it takes a horse (two, actually) to make a horse and a dog to make a dog. The mode of reproduction is the reason why like produces like.

If Harold and other molecular biologists are moving away from the 'genocentric' conception of life, toward what view are they moving? Summing up some of the discoveries molecular biologists have made, such as how proteins are transported to their proper destinations in the cell, Harold says, "These, to my mind are puzzles. The mystery lingers just beyond. (Speaking of *E. coli*) What pulls together the cacophony of

molecules and ion channels and regulated pathways into a coherent whole: a cylinder with rounded caps, quickly and every time? If a cell is an orchestra and DNA the score, who or what conducts?" (p. 113) If the conductor is seen as a principle of unity of substance, operation, and purpose, it is what we call the soul. And it is clear that this soul is not the genes, or molecules of any kind.

Granted that genes are not the essence or the soul, can we grant that changes in the genes might cause a change in essence? I hear Galen shouting, "I thought we agreed that nature is a long way prior to the corpuscles and not the other way around!" What Galen means is that the corpuscles or atoms do not exist prior to the nature of a given organism and get the name for that nature when they are put in a certain arrangement. In other words, the nature is not simply a name given to arrangement of atoms. Rather, in the development of an organism, nature is prior to the atoms and gives the organism the ability to attract atoms to itself and change them into its own substance. Genes serve as organs for the living cell and their operation is controlled by the cell and ordered to the good of the whole. Furthermore, the cell controls the replication of the DNA and the organelles of the cell move the chromosomes and separate them during mitosis and meiosis. In this sense the living cell is prior to the gene and determines how it will function and not the other way around. Mutations of the DNA take place in a living cell. This mutated DNA will either remain in this cell or be given to another living cell by cell-division. In either case the question will be whether the host cell, which already is a particular species, can make use of that DNA as an organelle for its own purposes. If it can make use of the DNA, the differences brought about would be accidental to the kind of cell that it already is. If the cell cannot make use of the mutation, then either there will be no change or a change deleterious to the life of the cell. Therefore, changes in DNA or genes alone cannot bring about a new species.

The above arguments are based on two important assumptions. First, that an organism is a unified whole, a single substance, made of parts (organs) which function as tools for the good of the whole organism. Secondly, each organism has an essence that makes it one and determines its species or kind.

Ernst Mayr, in an essay entitled "Basic Concepts of Evolutionary Biology," says that:

> Darwinism has a well-defined philosophical basis, an understanding of which is a prerequisite for the understanding of the evolutionary process. It has long been a puzzle for the historian of biology why the key to the solution of the problem was found in England rather than on the European continent. No other country in the world had such a shining galaxy of famous biologists in the middle of the last century as the Germany of Rudolphi, Ehrenberg, Karl E. von Baer, Schleiden, Leuchart, Siebold, Koelliker, Johannes Muller, Virchow, and Leydig, and yet the solution to the problem of evolution was found by two English amateurs, Darwin and Wallace, neither of whom had had thorough zoological training. How can one explain this? My answer is that the philosophical thinking on the continent was dominated at the time by essentialism. This philosophy . . . is quite incompatible with the assumption of gradual evolution. . . . By contrast, a very different kind of thinking, strongly supported by empiricism, had developed in England: the so-called population thinking, for which gradual evolution poses no difficulties. Population thinking is based on assumptions opposite to those of essentialism. It claims that only individual phenomena have reality and that every endeavor to infer from them an essence is a process of abstraction. Population thinking thus turns the dogma of essentialism upside down. The replacement of typological (essentialists) thinking by population thinking was perhaps the most important revolution in the history of biology.[2]

[2] Ernst Mayr. *Basic Concepts of Evolutionary Biology* in *Evolution and the Diversity of Life*. Selected Essays. 1997. First Harvard University Press paperback edition.

Recall that in the opening quotation Mivart attempts to explain what is denoted by the word species: ". . . a peculiar congeries of characters, innate powers and qualities, and a certain nature realized indeed in individuals . . ." but it is also a "common nature." Mayr, on the other hand, denies that there is a common nature. In fact, such an idea is incompatible with the gradualism of the Darwinian theory. All that exists in reality are individuals and populations of individuals. If we accept this definition of species, then, of course, evolution is a fact. With the birth or death of an individual there will be a change in the population, or a change in the gene frequency in a population. This is how evolution is defined.

Mayr bemoans the fact that many educated people, even biologists who are not specialists in evolutionary theory, are still not fully convinced that Darwinism is true. As he says, they have a feeling that although the argument sounds logical, something doesn't seem quite right. Don't we all know by ordinary experience that there are individuals with a common nature belonging to the same species. Most people would say that a Hairless Chihuahua and a Great Dane, although vastly different in many ways, share the same nature. This is why we call them by the same name, dog.

In destroying the ordinary notion of species Mayr, an amateur philosopher, follows his master, the amateur zoologist. Darwin devotes the first two chapters of the *Origin of Species* to destroying the notion of species. In Chapter 1, Darwin says,

> I look at the term species as one arbitrarily given, for the sake of convenience, to a set of individuals closely resembling each other, and . . . it does not differ essentially from the term variety, which is given to less distinct and more fluctuating forms. The term variety, again, in comparison with mere individual differences, is also applied arbitrarily, for convenience sake. (p. 46)

The difficulty raised by Darwin in this chapter is a real one. The variation in breeds of domestic animals brought about by selective breeding is indeed greater than that of so-called species found in the wild. Darwin uses this conundrum to bring into question whether the notion of species is anything other than a mere name imposed by men on groups of individuals which appear to be distinctive in some way. However, another solution to this difficulty readily comes to mind: taxonomists may have divided groups too finely, giving species designation to things that are really only varieties.

At the beginning of Chapter 2, Darwin says that he does not intend to discuss the various definitions which have been given to the term "species"—a strange move in an argument purporting to explain how species can be generated. This would be analogous to a geometer claiming that he can demonstrate the construction of an icosahedron without telling his listeners what it is. How is the hearer to judge whether the geometrician has accomplished his task?

In Chapter 14, Darwin claims that "extinction has only defined the groups: it has not made them; for if every form which has ever lived on earth were suddenly to reappear . . ." it would be quite impossible to give definitions by which each group could be distinguished. (p. 332) So, extinction has brought about gaps in the continuum of organisms which gives the appearance of differences in kind, but really there is no such difference. This greatly eases Darwin's task, for if differences among species are only an appearance and all species are actually the same in kind, then the generation of a bird from a reptile may be more readily accepted as a natural variation within a species.

> But I must explain my meaning more fully. I believe that the arrangement of the groups within each class, in due subordination and relation to each other, must be strictly genealogical in order to be natural; but that the amount of difference in the several branches or groups, though allied in the same degree in blood to their common progenitor, may

> differ greatly, being due to the different degrees of modification which they have undergone; and this is expressed by the forms being ranked under different genera, families, sections, or orders. The reader will best understand what is meant, if he will take the trouble to refer to the diagram in the fourth chapter. We will suppose the letters A to L to represent allied genera existing during the Silurian epoch, and descended from some still earlier form. In tree of theses genera (A, F, and I), a species has transmitted modified descendents to the present day, represented by the fifteen genera (a^{14} to z^{14}) on the uppermost horizontal line. Now all these modified descendents from a single species, are related in blood or descent in the same degree; they may metaphorically be called cousins to the same millionth degree; yet they differ wildly and in different degrees from each other. The forms descended from A, now broken up into two or three families constitute a distinct order from those descended from I, also broken up into two families. Nor can the existing species, descended from A, be ranked in the same genus with the parent A; or those from I, with the parent I. But the existing genus F^{14} may be supposed to have been but slightly modified; and it will then rank with the parent-genus F; just as some few still living organisms belong to Silurian genera. So that the comparative value of the differences between these organic beings, which are all related to each other in the same degree by blood, has come to be widely different. (pp. 323–324)

So the offspring of the same progenitors may end up being classified in different genera, families, or orders, etc, and may differ in the same way from their own progenitor. If the generated is truly different in species from the generator, the universal dictum 'like begets like' is contradicted. However, if dog is not really a different species than a cat or a bird from a reptile, then like is begetting like, but Darwin has explained nothing of significance. For there is no coming to be of new species.

We have argued in this paper that offspring get their spe-

cific form or species by participation in that of their parent. The life of the offspring begins by being a part of the parent and acquires its individuality by separation from the parent. If this is so, how can an offspring be a different species than its parent? If A begets B, the latter must be the same species as A. As we said earlier, this is what generation in the strictest sense means for living things. Therefore, if B begets C the latter is not only the same species as B but also as A. Evolutionists image that the natural, individual variation found within a species can, over numerous generations, be sufficient to merit a new species name. All we have to do is imagine a bird's beak getting longer, the shape of a wing or the color markings changing and we have a new species! This view not only glosses over what it means to be a species, it ignores what all biologists know, "like begets like." And by like, we do not mean like in every respect, but like in kind or species.

Let me close by saying that the recent findings in molecular and cell biology may force neo-Darwinists to come up with a new paradigm; for their account depends on the assumption that genes make an organism what it is. On the contrary, we have argued that it is the species of the parent that determines the species of the offspring; a life of a particular kind generates a life of the same kind. Furthermore, our deeper knowledge of living things also has proved, contrary to what Aristotle and the ancients thought about the various modes of spontaneous generation, that the dictum 'like begets like' extends to all organisms. As biologists learn more about the nature of life and living things the question is how well the imaginings of the neo-Darwinists will measure up to the way things really are. Darwin imagines that the generative powers of organisms, which can be affected by environmental influences, are a sufficient cause for the diversity of organisms. However, if our argument is correct, a cause beyond the generative power of organisms must be sought for the origin of species.

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