Natural Theology
or
Evidences of the Existence and Attributes of the Deity
collected from the appearances of nature

William Paley

1802

[Brackets] enclose editorial explanations. Small ·dots· enclose material that has been added, but can be read as though it were part of the original text. Occasional •bullets, and also indenting of passages that are not quotations, are meant as aids to grasping the structure of a sentence or a thought. In other texts on the website from which this one comes, four-point ellipses . . . . are used to indicate the omission of brief passages; in the present text such omissions are not noted, as there are too many of them. Paley was in many ways an excellent stylist, but he was enormously prolix, mostly through repetitions, which have been stripped out. Long omissions are reported between brackets in normal-sized type. —Paley provides dozens of references to works of anatomy, natural history, theology etc., which are omitted from the present version. —The division into numbered chapters is Paley's; some of the chapter-titles are not; and the division into unnumbered sections is not.

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Contents

Glossary

affect: As used in one paragraph on pages 75–76 this means 'be drawn to, have something like a desire for'. Paley seems to use it as the verb cognate with the noun 'appetency'.

appetency: A propensity or tendency to go after something. Broader in meaning than 'desire' or 'appetite', but sufficiently related to them for Paley to say on page 76 that the term can't be transferred from animals to plants.

art: Paley mainly uses this to refer to human skill, until page 44, after which the skill in question is sometimes God's or (the same thing, for Paley) nature's.

artificial: Made with skill. Quite often, the skill is God's.

artist: A human being who uses skill in making something. A watch-maker is an 'artist' even if there is nothing 'artistic', in our sense, about the watch. Similarly 'artificer'.

brute: sub-human animal, not necessarily 'brutal' or 'brutish' (as we would say).

contrivance: One of Paley's favourite words, it is equivalent to 'design'.

curious: Paley's meaning for this seems to be somewhere in the region of three of the OED's senses for it: 'exquisite, excellent, fine', 'interesting, noteworthy', 'deserving or arousing curiosity; strange, queer'.

elements: Paley uses this term mainly to refer to the traditional four: earth, air, fire, water. In chapter 21 ('Elements'), however, earth drops out; and both there and in chapter 17 light is included, as 'this new, this singular element'.

evil: bad. In early modern times it did not have as strenuous a meaning as it does today. Especially when used as a noun: 'the origin of evil' means 'the explanation of why there is anything bad in the universe'; a toothache would count as an evil.

faculty: Capacity, ability.

final cause: Goal, end aimed at, purpose. Paley uses the phrase quite often, but, oddly, not before page 37.

imperfection: When Paley speaks of the imperfection of some part of our knowledge (e.g. of chemistry) he means its incompleteness, its not yet being finished. Especially in chapter 7. In 'the evils of imperfection' (pages 88–89) the word means something more like what we mean by it today.

industry: work.

instrument: When on page 10 and elsewhere Paley insists that certain biological items are 'instruments', he means that they don't design anything; they are like the chisel, not the carpenter.

office: In Paley's day, a thing's 'office' was its role or function in some scheme of things. Similarly for the 'office' of a person.

original: An original feature of an organism is one that it had from the outset, not something it acquired later.

principle: Paley sometimes uses this word in a now-obsolete sense in which it means 'source', 'cause', 'driver', 'energizer', or the like. The phrase 'principle of order', which he mocks on pages 2 and 14, means 'something bringing it about that there is order in the world'.

probation: Testing someone's character, especially with a view to his fitness for the after-life.

second causes: intermediate causes, between God (the first cause) and whatever effects we are interested in.

station: Social standing, rank.

subservient: Serving as a means to an end (OED). Similarly 'subservience'.

11. The animal structure seen as a mass

Contemplating an animal body in its collective capacity, we must notice how many instruments are brought together, often within how small a compass. It is a cluster of contrivances. In a canary, for instance, in the single ounce of matter that composes its body, there are instruments for eating, digesting, nourishment, breathing, generation, running, flying, seeing, hearing, smelling—each appropriate for its purpose, each entirely different from all the others.

The animal frame, considered as a mass or assemblage, has in its composition three properties that have long struck me as indubitable evidences not only of design but of a great deal of attention and accuracy in carrying out the design. ·They will be the subjects of the next three sections·.

Symmetry and asymmetry

The first is, the exact correspondence of the two sides of the same animal; the right hand corresponding to the left, leg to leg, eye to eye, one side of the face to the other; and with a precision that is very difficult for a sculptor to imitate at all closely.

It is hard to get a wig made even, yet how seldom is the face awry! And the anatomy of its bones demonstrates what care is taken to preserve its symmetry. The upper part of the face is composed of thirteen bones, six on each side, matching each to each, and the thirteenth, with no partner, in the middle; the lower part of the face is similarly composed of six bones, three on each side, with the lower jaw in the centre. Could the builder of an arch do more to make the curve true, i.e. the parts equidistant from the middle, alike in shape and position?

Given how complex the eyes are in their structure, how various and delicate are the shades of colour that the iris is tinged with, how differently—so far as appearance is concerned—different eyes are mounted in their sockets in different heads, the resemblance of each eye to its partner is a property of animal bodies much to be admired. Of ten thousand eyes, I do not know that we could match one except with its own partner, or sort them into suitable pairs by any selection except the one that obtains.

This regularity of the animal structure is rendered more remarkable by the three following considerations.

a The individual limbs do not have not this correlation of parts, but the contrary of it. A knife drawn down the middle cuts the human body into two parts, externally equal and alike; you cannot draw a straight line that will divide a hand, a foot, the leg, the thigh, the cheek, the eye, the ear, into two parts equal and alike. The parts that are located on the middle line of the body, such as the nose, the tongue, the lips, can be so divided, but other parts cannot. This shows that the correspondence I have been describing does not arise necessarily from the nature of the subject; for if it did, it would be universal; whereas it is observed only in the system or assemblage, not in the separate parts. It is found where it conduces to beauty or utility; it is not found where it would detract from both. The two wings of a bird always correspond; the two sides of a feather frequently do not. In centipedes and their like, no two legs on the same side are alike, yet there is the most exact similarity between the legs opposite to one another.

b While the cavities of the body are so configured as to exhibit *externally* the most exact correspondence of the opposite sides, the *contents* of these cavities have no such correspondence. A line drawn down the middle of the breast divides the thorax into two exactly similar sides, but these sides enclose very different contents. The heart lies on the left side, a lobe of the lungs on the right, with no match in size or shape. The same thing holds for the abdomen. The liver lies on the right side, without any similar organ matching it on the left; the spleen, which is indeed situated over against the liver, doesn't resemble it in size or shape.

c An internal inequality in the feeding vessels is so managed as to produce no inequality in parts that were intended to correspond. The right arm answers accurately to the left, both in size and shape; but the arteries supplying the two arms do not go off from their trunk in a pair, in the same manner, at the same place, or at the same angle. Given this dissimilarity, it is very difficult to conceive how the same amount of blood would be pushed through each artery; yet so it is—the two limbs nourished by them perceive no difference of supply, no effects of excess or deficiency.

Packaging

Another surprising perfection of the animal mass is the package. Examine the contents of the trunk of any large animal, and notice how soft and intricate they are, how constantly in action, how necessary to life! Reflect on the danger of any injury to their substance, any change of their position, any obstruction to their office. Observe

- •the heart pumping at the rate of 80 strokes a minute, with one set of pipes carrying the stream away from it, another bringing it back;
- •the lungs performing their elaborate office, distending and contracting their many thousand vesicles by an alternation that cannot cease for a minute;
- •the stomach exercising its powerful chemistry;
- •the bowels silently propelling the changed aliment; collecting from it and transmitting to the blood an incessant supply of prepared nourishment;
- •that blood pursuing its course, with many glands—including the liver, the kidneys and the pancreas—drawing off from it their proper secretions.

All these operations, and others less capable of being investigated, are going on within us all at once. Think of this; and then observe how the body itself—the case that holds this machinery—is rolled and jolted and tossed about, with the mechanism remaining unhurt and with very little effect on even its most delicate motions. Observe this, and then reflect how firmly every part must be secured, how carefully surrounded, how well tied down and packed together!

This property of animal bodies seems never to have been considered as a separate topic, or as fully as it deserves. So allow me to support my remarks about it by briefly presenting anatomical details, though this obliges me to use more technical language than I would wish to introduce into a work of this kind. [Paley devotes about three pages to this, with details concerning •the heart, 'placed between two soft lobes of the lungs'; the lungs, 'tied to the sternum before and to the vertebrae behind'; the liver, 'fastened by two ligaments', one for holding the liver in place when our body is erect, the other for when we are lying down; •the bladder, 'tied to the navel by a ligament, so that what was a passage for urine to the fetus becomes after birth a support for the bladder'; •the kidneys, 'lodged in a bed of fat'; •the pancreas, 'strongly tied to the peritoneum'; •the spleen, confined to its place by an adhesion to the peritoneum and diaphragm'; and •the brain, whose septa 'probably prevent one part of that organ from pressing with too great a weight on another part'. He continues:] The great art and caution of packing is to prevent one thing from hurting another. In an animal body's head, chest and abdomen this is provided for—among other methods—by membranous partitions and wrappings that keep the parts separate.

The above may serve as a short account of how the principal viscera are kept in their places. But the most curious [see Glossary] provision for this purpose, in my opinion, and also the most needed, is in the guts. It is pretty evident that a long narrow tube (in man, about five times the length of the body)—

•laid in folds,
•winding in oblique and circuitous directions, and
•composed of a soft and yielding substance

—must be continually displaced by the sudden motions of the body that contains it, unless extraordinary precaution is employed its safety. The expedient provided for this is admirable. The intestinal canal, throughout its length, is knit to the edge of a broad fat membrane called the mesentery. It forms the margin of this mesentery, being fastened to it like the edging of a ruffle; it is four times as long as the mesentery itself, and is 'puckered or gathered on' to it as a seamstress would say. The mesentery is wide and thick, making it capable of a folding that is more close and safe than the intestinal tube would admit of if it had remained loose. This membrane, which appears to be the great support and security of the alimentary apparatus, is itself strongly tied to the first three vertebrae of the loins.

Beauty

A third general property of animal forms is *beauty*. I do not mean the beauty of one individual compared with another of the same species, or of one species compared with another species. What I am talking about is the provision that is made in the body of almost every animal to make its appearance acceptable to the animals it comes into contact with. In our own species, for example, consider the parts and materials the fairest body is composed of, and you will realise how well these things are wrapped up so as to form a mass that has symmetry in its proportion and beauty in its aspect: how the bones are covered, the bowels concealed, the roughnesses of the muscle smoothed and softened; and the whole is covered by an integument that converts the disgusting materials of a dissecting-room into something that can be looked on with affection or at least with ease and satisfaction. Much of this comes from the intervention of the cellular membrane that lies immediately under the skin as a kind of lining to it. This is moist, soft, slippery, and compressible, filling up all the interstices of the muscles and forming thereby their roundness and flowing line, as well as the evenness and polish of the whole surface.

This seems to be a strong indication of design, and of a design carefully directed to this purpose. And given that such a purpose exists with respect to any of nature's productions, we may with a considerable degree of probability assign other particulars to the same intention—the tints of flowers, the plumage of birds, the furs of beasts, the bright scales of fishes, the painted wings of butterflies and beetles, the rich colours and spotted lustre of many tribes of insects.

There are ornamental parts of animals whose beauty-making properties do not serve any other purpose that we know of. The irises of most animals' eyes are very beautiful, without their beauty conducing at all to the perfection of vision.

In plants, especially in their flowers, the principle of beauty holds a still more considerable place in their composition; is even more open than in animals. To take just one instance (there are hundreds), why does the corolla of the mature tulip change its colour? So far as we can see, the purposes of vegetable nutrition could have been carried on as well by its staying green. This has been called a disease of the plant, but that seems to be a lame account. Is it not more probable that this property, which seems to be independent of the needs and utilities of the plant—was calculated for beauty, intended for display?

It has been maintained that there is no such thing as beauty; that things come to be thought beautiful only because they are useful and familiar. Our idea of beauty can be so greatly modified by habit, fashion, the experience of advantage or pleasure, and associations arising out of that experience, that it has been suggested that it has been altogether generated by these causes and would have no existence without them. This seems to reach a conclusion that goes too far from its premises. I would rather argue as follows. The question concerns objects of •sight. Now, every other sense has its distinction of agreeable and disagreeable. Some •tastes offend the palate, others gratify it, even more strongly and regularly in brutes and insects than in man. Similarly, •smells affect the nose with sensations that are pleasurable or disgusting. Some •sounds or combinations of sounds delight the ear, others torture it. Habit can do much in all these cases (which is just as well for us, for habit reconciles us to many necessities); but does the distinction of agreeable and disagreeable have no foundation in the sense itself? What is true of the other senses is probably true of the eye (the analogy is irresistible), namely that it has an **original** constitution that is fitted to receive pleasure from some impressions and pain from others.

But I do not know that my argument alleging beauty as a final cause [see Glossary] requires me to claim so much. We do have a sense of beauty, however we come by it; it does in fact exist. Things are not indifferent to this sense; all objects do not suit it; many are agreeable to it, many others disagreeable. It is certainly not the effect of habit on the particular object, because the most agreeable objects are often the most rare; and many that are very common continue to be offensive. If they be made tolerable by habit, that is the most it can do; they never become agreeable. So if this sense is not original [see Glossary] but **acquired**, that is the outcome of numerous complicated actions of external objects on the senses, and of the mind on its sensations. With this result there must be a certain congruity to enable any particular object to please: and that congruity, we contend, is consulted in the aspect which is given to animal and vegetable bodies. [That last sentence is verbatim as Paley wrote it.]

The skin and covering of animals is what their appearance chiefly depends on, and is in all animals the part most decorated and free from impurities. But even if beauty had no place here, the throwing of an integument over the collocation of the parts of the body beneath it has another purpose—a even more important one—namely concealment. Were it possible to view through the skin the mechanism of our bodies, the sight would frighten us out of our wits. A lively French writer says: 'Would we dare to make a single movement if we saw our blood circulating, the tendons pulling, the lungs blowing, the humours filtrating, and all the incomprehensible assemblage of fibres, tubes, pumps, valves, currents, pivots, that sustain an existence that is at once so frail and so presumptuous?'

Standing

Animal bodies considered as masses have another property that is more curious than it is generally thought to be, namely the ability to *stand*. This is more remarkable in two-legged animals than in quadrupeds, and especially in man—the tallest, with the smallest base. The statue of a man, placed loosely on its pedestal, would not be upright for half an hour. If you don't fix its feet to the block by bolts and solder, the first gust of wind is sure to topple it. Yet this statue has all the mechanical proportions of a living man. So what keeps a man upright is not merely his shape or the relation of his centre of gravity to his base. Either the law of gravitation is suspended in favour of living substances, or something more is done for them to enable them to uphold their posture. There is no reason to doubt that their parts descend by gravitation as do the parts of dead matter. The 'something more' appears to me to consist in a capacity for perpetually shifting the centre of gravity, by a set of quick-balancing actions (obscure ones indeed), so as to keep within its prescribed limits the line from that centre to the ground. Of these actions it may be observed **a** that they in part constitute what we call strength. The dead body drops down. The mere adjustment therefore of weight and pressure, which may be the same the moment after death as the moment before, does not support the column; an in cases of extreme weakness, the patient cannot stand upright. **b** Also, these actions are only in a small degree voluntary. A man is seldom conscious of his voluntary powers in keeping himself on his legs. A child learning to walk is the greatest posture-master in the world; but the art (so to call it) sinks into habit, and the child is soon able to poise himself in a great variety of attitudes without being aware of either caution or effort. But there must be an aptitude of parts that habit can get hold of, a pre-habit capacity for motions that the animal is thus taught to exercise; and one of the things we wonder at it how easily this exercise is acquired. What parts are principally employed, and how each contributes its office, is difficult to explain. Perhaps the obscure motion of the bones of the feet have a share in it; they are put in action by every slip or vacillation of the body, and seem to assist in restoring its balance. The alternation of the joints (the knee-joint bending backward, the hip-joint forward) and the flexibility in every direction of the spine appear to be very important in preserving the body's equilibrium. Also a certain degree of tension in the sinews appears to be essential to an erect posture; for it is by the loss of this that the dead or paralytic body drops down. The whole is a wonderful result of combined powers and complicated operations. That *standing* is not as simple a business as we imagine it to be is evident from the strange movements of a drunken man who has lost control of his centre of gravity.

I have said that this property is most noteworthy in the human body; but a bird resting on its perch or hopping onto a branch provides a non-trivial example of the same faculty. Considered geometrically and with relation to its centre of gravity, its line of direction and its equilibrium, a chicken is a very irregular solid; but as soon as it is hatched from the egg it runs off. This cannot be something it has been taught. Can we not say that *nature* has balanced the chicken's body on its pivots?

Interrupted analogies

I shall present here ·three· examples of *patterns followed and then dropped*, which I call 'interrupted analogies'. I do not know how such critical deviations can possibly be accounted for without *design*.

(a) All the bones of the body are covered with a periosteum except the teeth. With them it ceases, and is replaced by an enamel of ivory that saws and files will hardly affect. No-one can doubt the use and propriety of this difference, of the rule for the conformation of the bones stopping where it does stop, of the 'analogy' being thus 'interrupted'. For if such an acutely sensitive membrane as the periosteum had covered the teeth as it does every other bone in the body, the animal would have been in continual pain because of the necessary exposure of the teeth. What *they* needed was a strong, hard, insensitive, defensive coat; and that is exactly what they are provided with by the ivory enamel that adheres to their surface.

(b) The epidermis that clothes all the rest of the body gives way at the extremities of the toes and fingers to nails. Just look at your hand to see how precisely the covering that extends over every other part is here superseded by a different substance with a different texture. Now, if **a** the rule had been necessary or **b** the deviation from it accidental, this effect would not be seen. **a** If the formation of the skin on the surface were produced by a set of causes constituted without design, acting by a general operation, no explanation could be given for the operation's being suspended at the fingers' ends, or on the back part of the fingers and not on the other part. **b** If the deviation were accidental—an error, an anomaly, anything but intentional—we would find nails on other parts of the body; they would be scattered over the surface, like warts or pimples.

(c) All the great cavities of the body are enclosed by membranes, except the skull. Why should not the brain be content with the same covering as the other principal organs of the body have? The heart, the lungs, the liver, the stomach, the bowels, all have soft integuments and nothing else. Their muscular coats are all soft and membranous. I can see a reason for this distinction in the final cause, but in no other.

The importance of the brain to life, and the extreme tenderness of its substance, give it a greater need for a solid case than any other part has; and that is what the hardness of the skull supplies. When the smallest portion of this natural casing is lost, how carefully yet how imperfectly is it replaced by a metal plate! There are other bony cavities in the body, but the skull differs from them in two ways: the bony covering completely surrounds its contents, and it is aimed not at motion but solely at defence. Also, the hollows and inequalities that we observe in the inside of the skull, exactly fitting the folds of the brain, serve the important purpose of keeping the substance of the brain steady and of guarding it against concussions.

12. Comparative anatomy

When we find a general plan being followed, with variations required by the particular demands of the subject to which it is applied, this gives us the strongest evidence—almost *conclusive* evidence—of intelligence and design. If the general plan proceeded from any fixed necessity in the nature of things, how could it accommodate itself to the various wants and uses which it had to serve under different circumstances, and on different occasions? [He likens this to a mill designed for spinning cotton and adapted for spinning wool, flax, and hemp, which provides overwhelming evidence that] intelligence, properly and strictly so called (including foresight, consideration, reference to utility) was at work in the original plan as well as in the changes and adjustments it is made to undergo.

Much of this reasoning is applicable to so-called *comparative anatomy*. Between all large terrestrial animals there is a close resemblance in their general economy, the outlines of the plan, the construction as well as offices [see Glossary] of their principal parts. Life is sustained and the body nourished by nearly the same apparatus in all of them. The heart, the lungs, the stomach, the liver, the kidneys are much alike in all. The same fluid (for no differences in kinds of blood have been observed) circulates through their vessels, and nearly in the same order. When we pass on to smaller animals, or to the inhabitants of a different element, the resemblance becomes more distant and more obscure; but still the plan accompanies us.

My present concern is to bring out how the general plan is varied and deflected by special occasions and utilities.

Coverings, especially feathers

I do not know whether I am correct in classing animals' covering under their 'anatomy', ·but it belongs in this chapter anyway·. The covering of different animals is the first thing that presents itself to our observation; and it is as much to be admired as any part of their structure, because of its variety and its suitableness to their various natures. There are bristles, hair, wool, furs, feathers, quills, prickles, scales; yet in this diversity both of material and form we cannot change one animal's coat for another without obviously changing it for the worse. (These coverings incidentally, are in many cases armour as well as clothing, intended for protection as well as warmth.)

The human animal is the only naked one, and the only one that can clothe itself. This is one of the properties that makes him an animal of all climates and all seasons. He can adapt the warmth or lightness of his covering to the temperature of his habitation. Had he been born with a fleece on his back, although he might have been comforted by its warmth in high latitudes, it would have oppressed him by its weight and heat as the species spread towards the equator.

What art [see Glossary] does for men has been done by nature for many animals that are incapable of art. Their clothing, of its own accord, changes with their necessities. This is particularly the case with the large tribe of quadrupeds covered by furs. Every dealer in hare skins and rabbit skins knows how much the fur is thickened by the approach of winter. It seems to be a part of the same design that in hot countries wool gives way to hair, whereas in dogs of the polar regions hair is replaced by wool or something very like it.

We know the final cause [see Glossary] of all this, and we know no other cause.

The covering of birds—

- its lightness,
- its smoothness,
- its warmth,
- the lay-out of the feathers, all inclined backward, the down about their stem, the overlapping of their tips,
- their different configuration in different parts, and
- the variety of their colours

—constitute a vestment for the body that is so beautiful, and so appropriate to the life the animal is to lead, that I don't think we can imagine anything more perfect, or could have imagined anything *this* perfect if we had never seen it.

This is one of those cases where the philosopher [here = 'scientist'] has more to admire than the common observer. Every feather is a mechanical wonder. The quill has strength and lightness—properties not easily brought together. I know few things more remarkable than the strength and lightness of the pen I am writing with right now. If we look at the upper part of the stem, we see a material made for the purpose and not used in any other class of animals or in any other part of birds: tough, light, pliant, elastic.

But the artificial [see Glossary] part of a feather is the beard. The 'beards' are what are fastened on each side of the stem and constitute the breadth of the feather; what we usually strip off from one side or both when we make a pen. The separate pieces or laminae of which the beard is composed are called 'threads' or 'filaments'. The first thing an attentive observer will notice is how much stronger the beard of the feather is when pressed in a direction perpendicular to its plane than when it is rubbed up or down in the line of the stem. And he will soon discover the structure that leads to this difference, namely that the laminae these beards are composed of are flat, and placed with their flat sides towards each other; so that while they easily bend to approach each other (as anyone can find by drawing his finger lightly upwards), they are much harder to bend out of their plane; and the latter is the direction in which they have to encounter the impulse and pressure of the air, and in which their strength is needed and put to the test.

A second special feature of a feather's structure is even more extraordinary. Whoever examines a feather cannot help noticing something about the threads or laminae of which I have been speaking, namely that

- in their natural state they hold together,
- their union is more than the mere apposition of loose surfaces,
- it takes some degree of force to pull them apart, yet
- there is nothing like glue between them;

so that by some mechanical means they catch or clasp among themselves, thereby giving to the beard its closeness and compactness of texture. Furthermore, when two laminae that have been separated by accident or force are brought together again, they immediately reclasp; the connection, whatever it was, is perfectly recovered and the beard of the feather becomes as smooth and firm as if nothing had happened to it. Try it for yourself.

The mechanism by which this remarkable contrivance is brought about is easy to see with a microscope:

> The threads or laminae are *interlaced* with one another, through a vast number of fibres that grow out from each side of the laminae and hook and grapple together. (A friend of mine counted fifty of these in one twentieth of an inch.) The fibres that come from the lamina on the side towards the tip of the feather are longer, more flexible, and bent downward; those that come from the side towards the feather's quill-end are shorter, firmer, and turned upwards. What happens is this: when two laminae are pressed together enough for the long fibres to be forced over the short ones, their crooked parts fall into the cavity made by the crooked parts of the others; just as the latch on a door enters the cavity of the catch fixed to the doorpost, and thereby fastens the door. It is strictly in this way that one thread of a feather is fastened to the next.

This admirable structure of the feather succeeds perfectly for the use nature has designed it for; not only that the laminae might be united, but that when one lamina has been separated from another by some external violence it might be easily and quickly reclasped.

In the small order of birds that winter with us, from the snipe downwards, whatever the external colour of their feathers is, their Creator has given them all a bed of black down next their bodies. Black is the warmest colour; and the purpose here is to keep in the heat arising from the heart and the circulation of the blood. It is noteworthy that this is not found in larger birds, because larger birds are much less exposed to the cold than small ones. [He explains why: the smaller the bird, the larger its surface in relation to its bulk. For a wren, the area of surface for each cubic inch of body is about ten times what it is for a turkey.] So small birds had to be more warmly clad than large ones, and the bed of black down seems to be the expedient by which that need is provided for.

Mouths

In comparing different animals, I know no part of their structure that exhibits greater variety, or a more precise fitting of that variety to their respective convenience, than their mouths. Whether the purpose is merely taking in food or

- catching prey,
- picking up seeds,
- cropping herbage,
- extracting juices,
- sucking in liquids,
- breaking and grinding food,
- tasting the food,

together with breathing in air and uttering sounds, these various offices are assigned to this one part, and are provided for by different constitutions in different species. In the human species, because there are hands to convey the food to the mouth, the mouth is flat and thus fitted only for reception; whereas the projecting jaws, wide mouth and pointed teeth of the dog and its relatives enable them to use their mouths to snatch and seize the objects of their pursuit. The full lips, rough tongue, corrugated cartilaginous palate and broad cutting teeth of the ox, the deer, the horse, and the sheep qualify this tribe for browsing on their pasture. The recessive under-jaw of a swine works in the ground, after the protruding snout, like a prong or plough-share, has made its way to the roots on which it feeds. Such a satisfactory conformation was not the gift of chance!

In birds this organ takes on a new character—new in substance and in form, and in both wonderfully adapted to the wants and uses of a distinct way of life. In place of the fleshy lips and teeth of enamelled bone, birds have a hard substance cut out into proper shapes and mechanically suited to the actions that are wanted. The sharp edge and tempered point of the sparrow's bill picks almost every kind of seed from its concealment in the plant, and then hulls the grain, breaks and shatters the coats of the seed, in order to get at the kernel. The hooked beak of the hawk tribe separates the flesh from the bones of the animals it feeds on, almost as cleanly and precisely as a dissector's knife. [He goes on to describe other kinds of beak and the uses to which they are put: butcherbird, goose, snipe and woodcock, and 'birds that live by suction'. These last, he reports, have filters inside the beak and near its edge.]

The likeness of the bills of birds to the mouths of quadrupeds suits my argument exactly: it is close enough to show the continuation of the same plan, and remote enough to show that the difference is not produced by action or use. A more prominent contour or a wider mouth might be explained as resulting from the species continually trying to thrust out the mouth or open it to the stretch. But by what course of exercise or endeavour can we get rid of the lips, the gums and the teeth, and acquire in their place pincers of horn? By what habit can we so completely change not only the part's shape but also the substance it is composed of? Everything about the animal mouth is mechanical. The teeth of fish have their points turned backward, like the teeth of a wool or cotton card; the teeth of lobsters work one against another, like the sides of a pair of shears; in many insects the mouth is converted into a pump or sucker, equipped to bore through the integuments of the insect's prey and then extract its juices. And—most extraordinary of all—one sort of mouth changes into another sort as the occasion requires. The caterpillar could not live without teeth; in several species, the butterfly formed from it could not use them. The old teeth therefore are cast off with the exoskeleton of the grub, and a quite different apparatus takes their place in the fly.

We sometimes forget that through all these novelties of form it is the animal's *mouth*, that whether it be lips, or teeth, or bill, or beak, or shears, or pump, it is the same part diversified.

Gullet and intestine

In the gullet also, comparative anatomy reveals a difference of structure adapted to the different needs of the animal. In brutes [see Glossary], because the posture of their neck doesn't much help the passage of the food, the fibres of the gullet, which act in this business, run in two close spiral lines, crossing each other; in men these fibres run only a little obliquely from the upper end of the esophagus to the stomach, into which by a gentle contraction they easily transmit the descending morsels. That is, for the more laborious swallowing of animals that thrust their food up instead of down, and also through a longer passage, a correspondingly more powerful apparatus of muscles is provided. It is more powerful not merely by the strength of the fibres, which might be attributed to the greater exercise of their force, but in their placing, which must have been original.

The gullet leads to the intestines, and here again, comparing quadrupeds with man, we find a general similarity with appropriate differences. The *valvuae conniventes* (which some call the 'semilunar valves') found in the human intestine are lacking in that of brutes. These are wrinkles in the innermost coat of the guts, which slow down the movement of the food through the alimentary canal. It is easy to understand how much more necessary such a provision is to **a** the body of an animal with an erect posture, where the weight of the food is added to the action of the intestine, than to **b** the body of a quadruped, where the food's journey from entrance to exit is nearly horizontal; but to explain why this difference actually exists we have to resort to the final cause. Mightn't the system of wrinkles have been caused by the action of the intestine? No! If it were, we would find it in **b** quadrupeds rather than in **a** men.

We should attend to the different length of the intestines in carnivorous and herbivorous animals. The shortest, I believe, is that of some birds of prey in which the intestinal canal is little more than a straight passage from the mouth to the anus. The longest is in the deer kind. The intestines of a four-feet-high Canadian stag measure 96 feet. The intestine of a sheep, unravelled, measures 30 times the length of the body. The intestine of a wild cat is only three times the length of the body. Universally, where the substance the animal feeds on is slow to digest, or yields its chyle with more difficulty, there the passage is circuitous, so as to allow time and space for the necessary change and absorption. Where the food is soon dissolved, or already half assimilated, a shorter and a readier route is provided, so as to avoid an unnecessary or perhaps harmful delay.

The special needs of birds

In comparing the bones of different animals, we are struck with how the bones of birds are appropriate in a way that could only come from the wisdom of an intelligent and designing Creator. An animal that is to fly needs bones that are **strong** and **light**. Well, then, how do the cylindrical bones of birds differ in these respects from the bones of quadrupeds? •Their cavities are much larger in proportion to the weight of the bone than in the bones of quadrupeds. •These cavities are empty. •The shell is of a firmer texture than is the substance of other bones. Now, the weight being the same, the diameter will obviously be greater in a hollow bone than in a solid one, and any mathematician can prove that (other things being equal) the greater the diameter of a cylinder the greater its strength, its resistance to breaking. In short, a bone of the same weight would not have been so **strong** in any other form; and making it less **light** would have hampered the animal's flight. This form could not be acquired by use, or the bone become hollow by exercise.

As compared with the lungs of quadrupeds, the lungs of birds also have a feature that is unique to them and conspicuously designed for this same purpose of flight, namely a communication between the air-vessels of the lungs and the cavities of the body. This allows air to pass from one to the other (at the will, apparently, of the animal), so that its body can be occasionally puffed out and its specific gravity—its tendency to descend in the air—made less. The bodies of birds are inflated from their lungs and thus made buoyant.

All birds are oviparous. This carries on the work of gestation with as little increase as possible of the weight of the body. A gravid uterus [i.e. one heavy with fetuses] would have been a troublesome burden to a bird in its flight. The advantage of an oviparous procreation is that, while the whole brood are hatched together, the eggs are laid singly and at considerable intervals. Ten, fifteen, or twenty young birds may be produced in one clutch though the parent bird was never burdened by the load of more than one full-grown egg at a time.

Means of travel

A principal topic of comparison between animals is in their instruments of motion, which we encounter in three categories: feet, wings, and fins. If any of the three is best fitted for its use, which is it? Is it not rather that the same consummate art is conspicuous in them all? Because of differences in the elements in which the motion was to be performed—·ground, air, water·—the Creator had to prepare for different situations and difficulties; but the purpose is accomplished just as successfully in each case as in the others. And as between wings and the legs of quadrupeds it is accomplished without deserting the general idea. The idea is modified, not deserted. Strip a wing of its feathers and it looks significantly like the foreleg of a quadruped. The articulations at the shoulder and the cubitus are much alike, and in both cases the upper part of the limb consists of a single bone, the lower part of two.

But when the wing is fitted up with its equipment of feathers and quills, it becomes a wonderful instrument; and the way the bird uses it in flying is more complicated and more curious [see Glossary] than is generally known. If the flapping of the wings in flight were merely the reciprocal motion of the same surface in opposite directions, the bird would lose as much by its upwards motion as it gained by the downwards one. To account for the advantage the bird derives from its wing, therefore, we must suppose that the surface of the wing (measured on the same plane) is contracted while the wing is drawn up, and let out to its full expansion when it descends. Now, the form and structure of the wing—

- its external convexity,
- the disposition and particularly the overlapping of its larger feathers,
- the action of the muscles, and
- the joints of the pinions

—are all adapted to this alternate adjustment of its shape and dimensions. For example, such a twist is given to the great feathers of the wing that going down they strike the air with their flat side, but rise from the stroke slantwise. The turning of the oar in rowing when the oarsman advances his hand for a new stroke is a similar operation to that of the feather, and takes its name, ·'feathering'·, from the resemblance. This faculty [see Glossary] is not found in the great feathers of the tail, I believe. This is the place to point out that the pinions are set on the body in such a way as to bring down the wings in a direction obliquely tending towards the tail; which motion does two things at once—supports the body in the air and carries it forward. The steering of a bird in its flight is effected partly by the wings, but mainly by the tail. And in this matter we meet with a remarkable circumstance: birds with long legs have short tails; and in their flight place their legs close to their bodies while stretching them out backwards as far as they can. In this position the legs extend beyond the rump and become the rudder, providing the steering that the tail could not.

There is an easy transition from the wings of birds to the fins of fish. They are both instruments of motion, with a considerable difference in the work they have to do, because fish have nearly the same specific gravity as the element they move in, whereas birds do not. So fish have little or no weight to bear up; what is needed is only a sufficient impulse to carry the body through a resisting medium, or to maintain the posture, or to support or restore the balance of the body, which is always the most unsteady where there is no weight to sink it. For these offices, the fins are as large as necessary, though much smaller than wings, their action mechanical, their position and the muscles by which they are moved highly convenient. [Paley goes on to say that this is confirmed by experiments that have been performed on fish, offers a 'short account' of these, and seems untroubled by their vivisectional nature. He then moves on to their upshot:] The pectoral and more particularly the ventral fins serve to raise and lower the fish; when the fish wants to move backwards, a stroke forward with the pectoral fin does that; if it wants to turn either way, a single blow with the tail the opposite way sends it round; if the tail strikes both ways, the double lash moves the fish forwards with an astonishing velocity. The result is not only in some cases the most rapid, but in all cases the most gentle, pliant, easy, animal motion that we are acquainted with. In their mechanical use, the anal fin may be reckoned the keel; the ventral fins, out-riggers; the pectoral muscles, the oars.

We have seen that the tail in the fish is the great instrument of motion. Now, in cetaceous or warm-blooded fish that have to rise every two or three minutes to the surface to breathe, the tail—unlike that of other fish—is horizontal; so its stroke is perpendicular to the horizon, which is the right direction for sending the fish to the top or carrying it down to the bottom.

In looking at animals' instruments of motion, I have followed the comparison only through the first great division into beasts, birds, and fish. If I wanted to go further, I would take in the special feature of the web-foot of water fowl. It is an example that could be pointed out to a child. It is so obvious that webbed feet are useful to water-fowl and would not be to land fowl that it seems impossible to notice the difference without acknowledging the design. I am at a loss to know how those who deny the agency of an intelligent Creator deal with this example. There is nothing in the action of swimming, as carried on by a bird on the surface of the water, that would generate a membrane between the toes. The only supposition I can think of is that all birds were originally water fowl and web-footed, and that sparrows, hawks, linnets, etc. have in the course of many generations had this part worn away by treading on hard ground. To such evasive assumptions must atheism always have recourse!

The five senses

The five senses are common to most large animals. We have not much difference to remark in their constitution, and less that is referable to mechanism.

The superior sagacity of animals that hunt their prey and consequently depend for their livelihood on their nose is well known in its use; but not at all known in the organisation that produces it.

The external ears of beasts of prey have their trumpet part standing forwards, to seize the sounds that are ahead of them, i.e. the sounds of the animals they are pursuing or watching. The ears of animals of flight are turned backward, to give notice of the approach of their enemy from behind. This is a critical distinction, and is mechanical; but it is quite likely to be an effect of continual habit ·rather than an upshot of intelligent design·.

The eyes of animals that follow their prey by night—cats, owls, etc.—have a faculty not given to the eyes of other species, namely of closing the pupil entirely. The final cause of this seems to be as follows. It was necessary for such animals to be able to discern objects with very small degrees of light. This capacity depended on the superior sensitivity of the retina, i.e. on its being affected by the most feeble impulses. But the tenderness of structure that made the membrane so sensitive also made it liable to being harmed by the access of stronger degrees of light. So the contractile range of the pupil is increased in these animals, so that at all times the only portions of light that are admitted are ones that can be received without injury to the sense. And this power of diminishing the admitted light in every degree includes the power to close the aperture entirely.

There appears to be also in the shape of the pupil of the eye an appropriate relation to the wants of different animals . In horses, oxen, goats, sheep, the pupil of the eye is elliptical, the transverse axis being horizontal. By this structure, although the eye is placed on the side of the head, the elongation of the front of the pupil catches rays coming from objects immediately in front of the animal's face.

13. Peculiar organisations

I believe that all the examples I shall collect under this heading could, consistently enough with technical language, have been classified as 'Comparative Anatomy'. But the way that phrase has come to be used seems to me to be improper: it is rather absurd to speak of *comparative* anatomy when there is nothing to compare—where one animal has a conformation that has nothing corresponding to it in another. The examples I shall present in the present chapter are like that. You will see that they must necessarily be of an unconnected and miscellaneous nature (though some of them are among the strongest supports for my over-all argument.) To dispose them, however, into some sort of order, we will notice, first, particularities of structure which belong to •quadrupeds, birds, and fish as such, or to •many of the kinds included in these classes of animals, and then to •such particularities as are confined to one or two species. [That last sentence is taken verbatim from the original.]

Features of quadrupeds, birds, and fish as such

(1) Along each side of the neck of large quadrupeds runs a stiff, robust cartilage, braced from the head to the middle of the back. Its office is to help support the weight of the head. It is a mechanical provision, of which this is the undisputed use; and it is sufficient (and not more than sufficient) for its purpose. The head of an ox or a horse is heavy, acting at the end of a long lever (consequently with a great purchase) in a direction nearly perpendicular to the joints of the supporting neck. The bones of the neck would be in constant danger of dislocation if they were not fortified by the cartilage I am speaking of. No such organ is found in the human subject, because there the weight of the head acts nearly in the direction of the spine, so that the junction of the vertebrae appears to be sufficiently secure without it. So this cautionary expedient is limited to quadrupeds: the Creator's care is seen where it is wanted.

(2) The oil that birds prune their feathers with, and the organ that supplies it, is provided specifically for the winged creation. On each side of the rump of birds there is a small nipple, yielding on pressure a butter-like substance which the bird extracts by pinching the nipple with its bill. The bird dresses its coat with this oil or ointment, repeating the action as often as its own sensations teach it that it is in any part wanted. The gland, the nipple, the nature and quality of the excreted substance, the manner of obtaining it from its storage in the body, the application of it when obtained, collectively form an evidence of *intention* that it is not easy to withstand. Nothing like it is found in unfeathered animals. What blind drive of nature would produce it in birds and not produce it in beasts?

(3) The air-bladder of a fish provides a plain and direct example of contrivance, and indeed strictly of mechanical contrivance. The principle of the contrivance is clear, and so is the application of the principle. The use of the organ to sustain and to elevate the body of the fish in the water is proved by observing that when the bladder is burst, the fish grovels at the bottom; and also, that flounders, soles, skates, that do not have the air-bladder, seldom rise in the water and do so only with effort. It is easy to see how the purpose is attained, and the suitableness of the means to the end. The rising and sinking of a fish in water, so far as it is independent of the stroke of the fins and tail, can only be regulated by the body's specific gravity. When the bladder in the body of the fish is contracted—which the fish probably has a muscular power of doing—the bulk of the fish is contracted along with it; so the specific gravity is increased and the fish descends; and a reversal of this processes brings it up. A diving machine might be made to ascend and descend on the same principle, by inserting into it an air-vessel that could change the bulk of the machine by its contracting or expanding, thus making the machine specifically heavier or specifically lighter than the water around it. Suppose someone did this, and sought to get a patent for his invention. The patent inspectors, whatever they thought regarding the value of the contrivance, could not possibly entertain a question in their minds whether it *was* a contrivance. No reason has ever been assigned—no reason *can* be assigned—why the conclusion is not as certain in the fish as it is in the machine, why the argument is not as firm in one case as the other.

It would be interesting to learn *how* an animal that lives constantly in water can supply a repository of air. Its way of doing this, whatever it be, is a part, and perhaps the most curious part, of the provision. Nothing like the air-bladder is found in land-animals; and a life in the water has no natural tendency to produce a bag of air. Nothing can be further from an acquired organisation than this is.

Features of many kinds included in these classes

(1) The fang of a viper is a clear and curious example of mechanical contrivance. It is a perforated tooth, loose at the root; in its quiet state it lies flat on the jaw, but it is provided with a muscle which, with a jerk, suddenly erects it. Under the tooth, close to its root and communicating with the perforation, lies a small bag containing the venom. When the fang is raised, the closing of the jaw presses its root against that bag, and the force of this compression shoots the venom out through the tube in the middle of the tooth. What more straightforward or effective apparatus could be devised for inflicting the wound while also injecting the poison? Though lodged in the mouth, it is so constituted that in its quiescent state it does not interfere with the animal's receiving food.

(2) The pouch of the opossum (and of several other species) is a strictly mechanical contrivance. Its simplicity makes the contrivance more obvious than many others, and by no means less certain. A false skin under the animal's belly forms a pouch into which the young litter are received at their birth; where they have easy and constant access to the teats; in which they are transported by the mother from place to place; where they are at liberty to run in and out; and where they find a refuge from surprise and danger. It is their cradle, their asylum, and the machine for their conveyance. The pouch is not a mere doubling of the skin; it is a new organ, provided with bones and muscles of its own—bones to anchor and support the muscles, which serve to open and close the pouch doing this so exactly that in the living animal the opening can hardly be seen except when the sides are forcibly drawn asunder. Is there any action in this part of the animal, any process arising from that action, by which these members could be formed? Can the whole formation be explained in any way except as arising from design?

(3) The middle claw of the heron and cormorant is toothed and notched like a saw. These birds are great fishers, and these notches help them to hold their slippery prey. The use is evident; but the structure cannot be accounted for by the effort of the animal or the exercise of the part. Some other fishing birds have these notches in their bills, for the same purpose; and here again the structure cannot arise from the manner of employing the part. The smooth surfaces and soft flesh of fish were less likely to notch the bills of birds than the hard bodies on which many other species feed.

Features confined to one or two species

(1) The stomach of the camel is well known to retain large quantities of water, and to hold it unchanged for a considerable length of time. This qualifies it for living in the desert. Let us see what the internal organisation is that this rare and beneficial faculty depends on. A number of distinct sacs or bags (in a dromedary thirty of these have been counted) lie between the membranes of the second stomach, and open into the stomach near the top by small square apertures. After the stomach is full, the annexed bags are filled from it through these apertures: and the water so deposited is

- not liable to pass into the intestines,
- kept separate from the solid food, and
- out of the reach of the digestive action of the stomach.

It appears pretty certain that the animal, by the conformation of its muscles, has the power to squeeze this water back from the adjacent bags into the stomach whenever thirst stimulates it to put this power in action.

(2) The tongue of the woodpecker is one of those singularities that nature presents us with when a singular purpose has to be met. The woodpecker lives chiefly on insects lodged in the bodies of decayed or decaying trees. For the purpose of boring into the wood it is provided with a bill that is straight, hard, angular, and sharp. When it has reached the cells of the insects by means of this piercer, its tongue comes into play. This tongue is

- so long that the bird can dart it out three or four inches from the bill, very unlike every other species of bird;
- tipped with a stiff, sharp, bony thorn, which is dentated on both sides, like the beard of an arrow or the barb of a hook (which appears to me the most remarkable property of all).

The bird, having exposed the retreats of the insects by the assistance of its bill, with an inconceivably quick motion launches this long tongue out at them, transfixes them on the barbed needle at the end of it, and draws them into its mouth. If this is not mechanism, what is? You might say that by continual endeavours to shoot out the tongue to the limit, the woodpecker's species has gradually lengthened it beyond that of other birds; but how did the tongue get its barb, its dentation? These barbs seem to me to be decisive proofs of mechanical contrivance.

(3) I shall add one more example, for the sake of its novelty. It is always an agreeable discovery when, having noticed an extraordinary structure in an animal, we eventually find out an unexpected use for it. Here is an example of that. The babyrouessa, or Indian hog, a species of wild boar found in the East Indies, has two bent teeth, more than half a yard long, growing upwards, and (which is the singularity) from the *upper* jaw. These instruments are not wanted for offence, which is provided for by two tusks that issue from the lower jaw and resembling those of the common boar; nor does the animal use them for defence. So they might seem to be a superfluity and an encumbrance. But observe the events!—the animal sleeps standing, and in order to support its head it hooks its upper tusks on the branches of trees.

14. Prospective contrivances

I can hardly imagine a more distinguishing mark of design, and thus a more certain proof of it, than *preparation*, i.e. the provision in advance of things that are not to be used until much later; for this implies a contemplation of the future, which belongs only to intelligence.

The bodies of animals provide various examples of such prospective contrivances. ·I shall describe four of them·.

(1) Human teeth provide an example not only of prospective contrivance but of the completion of the contrivance being designedly suspended. The teeth are formed within the gums, and there they stop: their further advance to maturity would be worse than useless to the new-born animal, because the act of sucking by which it is for some time to be nourished will be easier for the nurse and the infant if the inside of the mouth and edges of the gums are smooth and soft than if they are set with hard pointed bones. By the time the teeth are wanted, they are ready. They have been lodged within the gums for some months past, but detained in their sockets for as long as their further protrusion would interfere with the mouth's office [see Glossary]. Nature—i.e. the intelligence that was employed in creation—looked beyond the first year of the infant's life; but while providing for functions that would become necessary after that, it was careful not to inconvenience those that preceded them.

And the prospective contrivance looks still further: beneath the first crop of teeth a second tier is formed from the beginning, though they do not come into use till several years later. This double provision solves a difficulty in the mechanism of the mouth that would have appeared almost unsurmountable. The expansion of the jaw (resulting from the proportional growth of the animal and of its skull) necessarily separates the teeth of the first set to a distance from one another that would be very inconvenient. So when the jaw has attained a great part of its dimensions, a new set of teeth springs up (loosening and pushing out the old ones before them), more exactly fitted to the space which they are to occupy.

(2) It is hard to conceive a more obviously prospective contrivance than the one that is found, in all viviparous animals, in the milk of the female parent. At the moment the young animal enters the world, there is its maintenance ready for it. The particulars to be noted in this economy are neither few nor slight:

(i) the nutritious quality of the fluid, unlike every other excretion of the body;
(ii) the organ for its reception and retention;
(iii) the excretory duct annexed to that organ; and
(iv) the milk's being sent to the breast at the exact time when it is about to be wanted.

We have all these properties in the subject before us, and they are all indications of design. The **(i)** nutritiousness of the fluid is not imitated elsewhere in nature, neither cookery nor chemistry having been able to make milk out of grass. And **(iv)** is the strongest evidence of design. If I had tried to guess beforehand, I would have conjectured that at the time when there was an extraordinary demand for nourishment in one part of the system, there would be the least likelihood of a redundancy to supply another part. The advanced pregnancy of the female has no intelligible tendency to fill the breasts with milk. The lacteal system is a constant wonder; and it adds to other causes of our admiration that the number of the teats in each species bears a proportion to the number of the young. The simplest explanation of this is that it comes from a designing Creator.

(3) The eye is of no use at the time when it is formed. It is an optical instrument made in a dungeon; constructed for the refraction of light to a focus, and perfect for its purpose, before a ray of light has access to it; geometrically adapted to the properties and action of an element with which it has no communication. It is indeed going to enter into that communication, and this is exactly the thing that evidences *intention*. It is 'providing for the future' in the strictest sense of that phrase: it is providing

- not for the then-existing condition of the animal, and
- not for any gradual progress or advance in that same condition, but
- but for a *new* state, the consequence of a great and sudden alteration that the animal is to undergo at its birth.

Is it to be believed that the eye was formed without a view to this change? without a prospect of that condition in which its currently useless fabric is about to be of the greatest use? without a consideration of the qualities of the (hitherto entirely excluded) element with which it would later have such an intimate a relation? A young man makes a pair of spectacles for himself for when he grows old, having no use for them at the time he makes them. Could this be done without knowing and considering the defect of vision to which advanced age is subject? The precise suitableness

- of the instrument to its purpose,
- of the remedy to the defect,
- of the convex lens to the flattened eye

—wouldn't all this show for certain that the future vision troubles had been considered beforehand, speculated on, provided for? all of which are exclusively the acts of a reasoning mind. The eye formed in one state for use only in a different state provides a proof no less clear of being aimed at a future purpose; and a proof proportionally stronger as the machinery is more complicated and the adaptation more exact.

(4) What I have said of the eye holds equally true of the lungs. Composed of air-vessels where there is no air, and elaborately constructed for admitting and expelling an elastic fluid where no such fluid exists, this great organ (with the whole apparatus belonging to it) lies collapsed in the fetal thorax, yet all ready for action the moment its service is needed. This involves having a machine stored for future use, which incontestably proves that it was *expected* that such a use might occur; and *expectation* is the proper act of intelligence. Considering the state of an animal before its birth, I would expect nothing less in its body than a system of lungs. It is like finding a pair of bellows at the bottom of the sea—useless in the situation they are found in, formed for an action that could not possibly be performed, and having no relation or fitness to the element that surrounds them but only to another element in another place.

[He adds details about the openings in the fetus's heart that enable to blood to circulate before there are functioning lungs for it to go through, openings that close after the fetus is born. Paley concludes:] If this is not contrivance, what is?

Given that the action of the air on the blood in the lungs appears to be necessary to the life and health of the animal, how does the fetus live, grow and thrive without it? The answer is that the blood of the fetus is the mother's; that one pair of lungs serves for both.

15. Animate-to-animate relations

When an effect is produced by the joint action of different instruments, the fitness of such instruments to one another for the purpose of producing the effect, is what I call *relation*; and wherever this is observed in the works of nature or of man, it appears to me to bring decisive evidence of understanding, intention, art. In examining the various parts of a watch—the spring, the barrel, the chain, the fusee, the balance, the wheels of various sizes, forms, and positions—what would most strongly strike an observer as evidence of thought, deliberation, contrivance? It is the suitableness of these parts to one another, in •the order in which they act and •the effect they jointly produce. [Paley describes in great detail the physical features of the watch's parts that are explained by their intended collaboration.] What thus struck his attention in the various parts of the watch he could plausibly give the general name 'relation'; and, observing that such relations were found in things produced by art and design and in no other things, he would rightly regard them as characteristic of such productions. (I am speaking of things whose origin and formation could be ascertained by evidence.)

Now, animal economy is full of these relations—it is made up of them.

(1) There are, first, the parts and powers of animals that successively act on their food. Compare this action with the process of a factory. In men and quadrupeds, the food is

- **(i)** broken and bruised by mechanical instruments of mastication, namely sharp spikes or hard knobs, rubbing on one another;
- **(ii)** carried by a pipe into the stomach, where it undergoes the chemical action we call 'digestion';
- **(iii)** delivered, through an orifice that opens and shuts as needed, into the first intestine where it is further dissolved; and then
- **(iv)** the part of the chyle needed for animal nourishment is strained off through tiny tubes opening into the cavity of the intestines; after which
- **(v)** the strained, percolated fluid is carried into the blood-stream which conveys it to every part of the body.

Now I say again, compare this with the process of a factory, with the making of cider, for example, where the apples are

(i) bruised in the mill, then

(ii) fermented in the vat, after which the liquor is

(iii) put into in the hogsheads,

(iv) drawn off into bottles, and then

(v) poured out into glasses to be consumed.

Let anyone show me any difference between these two cases in regard to *contrivance*. The 'relation' of the parts successively employed (our present topic) is no clearer in the second case than in the first. [He goes through them in detail.] The character of the machinery is in both cases this, that one part answers to another part, and every part to the final result.

This parallel might be carried into further detail. Spallanzani has reported a point in which the stomachs of poultry and game birds resemble the structure of corn-mills. For purposes of this comparison, the two sides of the gizzard do the work of the millstones, and the craw corresponds to the hopper. When our fowls are abundantly supplied with food, they soon fill their craw; but it does not immediately pass on into the gizzard, but always enters in very small quantities, in proportion to the progress of grinding. In the same way, in a mill a receiver is fixed above the two large stones that grind the corn; and although the corn is put into the receiver in bushels it allows the grain to dribble only in small quantities into the central hole in the upper millstone.

But we have not done with the alimentary history. There is a general relation between the external organs by which animal it procures its food and the internal powers by which it digests it. [He gives details.]

(2) The relation of the kidneys to the bladder, and of the ureters to both—i.e. of the secreting organ to the vessel receiving the secreted liquor, and of both to the pipe laid between them to convey it from one to the other—is as obvious as the relations among the different vessels employed in a distillery and the pipes between them. Because in this case the animal structure is simple and the parts easily separated, it is an example of correlation that can be presented by dissection to every eye. This correlation of instruments to one another fixes *intention* somewhere.

Especially when the conformation rules out every other solution. If the bladder had been merely an expansion of the ureter, produced by retention of the fluid, there ought to have been a bladder for each ureter. One receptacle, fed by two pipes issuing from different sides of the body yet both conveying the same fluid is not to be accounted for by any such supposition as this.

(3) Relation of parts to one another accompanies us throughout the whole animal economy. Can any relation be more simple or more convincing than the fact that the eyes are so placed as to look in the direction in which the legs move and the hands work? It might have happened very differently if it had been left to chance. Any considerable alteration in the position of the eye or the shape of the joints would have disturbed the line and destroyed the alliance between the sense and the limbs.

(4) But *relation* is perhaps never more striking than when it holds between different things rather than between different parts of the same thing. The relation between a lock and a key is more obvious than the relation between different parts of the lock. A bow was designed for an arrow, and an arrow for a bow; and their being separate implements makes the design more evident.

Nor do the works of the Deity lack this clearest species of relation. The sexes are manifestly made for each other. They form the grand relation of animated nature:

•universal,
•organic,
•mechanical,
•subsisting in different individuals, like the clearest relations of ·human· art,
•unequivocal, and
•inexplicable without design.

So much so that if every other proof of contrivance in nature was dubious or obscure, this alone would be sufficient. The example is complete. Nothing is lacking for the argument. I see no way whatever of getting over it.

(5) The teats of animals that give suck have a relation to the mouth of the suckling progeny, particularly to the lips and tongue. This is another case of correspondence between parts of different individuals.

These are relations of parts that are found in all animals or in large classes of animals. I now describe some examples of the same kind of thing in certain species of animals.

In the swan,

•the web-foot,
•the spoonbill,
•the long neck,
•the thick down, and
•the graminivorous stomach

all have a relation to one another, in that they all fit into the single design of meeting the needs of an aquatic fowl floating on the surface of shallow pools of water and seeking its food at the bottom. Start with any one of these structural details and observe how the rest follow it. The web-foot qualifies the bird for swimming; the spoon-bill enables it to graze; but for that it needs a long neck. [And so on.] Or start with some other distinctive part of the swan's body, such as the long neck. Without the web-foot, the long neck would have been an encumbrance to the bird; yet there is no necessary connection between a long neck and a web-foot. In fact they do not usually go together. So how does it happen that they meet only when a particular design demands the aid of both?

This mutual relation, arising from a subservience [see Glossary] to a common purpose, is very observable also in the parts of a mole. The strong short legs of that animal, the palmated feet armed with sharp nails, the pig-like nose, the teeth, the velvet coat, the small external ear, the sensitive smell, the sunk, protected eye, all serve the utilities or the safety of its underground life. [Paley spells this out in considerable detail, including this charming bit:] The plush covering, which by the smoothness, closeness, and polish of its short piles rejects the adhesion of almost every species of earth, defends the animal from cold and wet, and from the impediment it would experience if the mould stuck to its body. From soils of all kinds the little pioneer [here = 'excavator'] comes forth bright and clean. Inhabiting dirt, it is the neatest of all animals.

16. Relations: compensation

Compensation is what we have when the defects of one part or organ are made up for by the structure of another part or organ. Here are some examples.

(1) The short unbending neck of the elephant is compensated by the length and flexibility of its trunk. He could not have reached the ground without it; and if you suggest that he could have fed on the fruit, leaves, or branches of trees, how was he to drink? Why is the elephant's neck so short? Perhaps because the weight of such a heavy head could not have been supported at the end of a longer lever. Thus, to a form that is in some ways necessary but in others inadequate to the animal's needs, a supplement is added which exactly makes up the deficiency under which he laboured.

A general hypothesis by which some people have recently tried to explain the forms of organisms would imply that this trunk was produced, over many generations, by the elephant's constant attempt to thrust out his nose. To anyone who accepts this, I ask: How was the animal to survive during the process, until this prolongation of its snout was completed? What was to become of the *individual* while the *species* was perfecting?

My present concern is simply to point out how this organ relates to the animal's shape: the necessity of the elephant's trunk arises from the shortness of his neck; the shortness of the neck is made necessary by the weight of the head. If we examine the structure of the trunk itself, we'll see one of the most curious of all examples of animal mechanism, namely the lay-out of the ringlets and fibres for the purpose of

•forming a long cartilaginous pipe,
•contracting and lengthening that pipe, and
•turning it in every direction at the will of the animal;

with the addition at the end of a fleshy production, like a finger and performing the office of a finger, so as to pick up a straw from the ground. These properties of a single organ constitute a prime example not only of design but of consummate art and of elaborate preparation in accomplishing that design.

(2) The hook in the wing of a bat is a strictly mechanical compensating contrivance. At the angle of its wing there is a bent claw by which the bat attaches itself to the sides of rocks, caves, and buildings. It hooks itself by this claw, remains suspended by this hold, and takes its flight from this position—operations that compensate for the decrepitude of its legs and feet. Without the hook, the bat would be the most helpless of all animals, unable to run on its feet or raise itself from the ground. In placing a claw on that part, the Creator departed from the usual pattern of winged animals. A singular defect required a singular substitute.

(3) Birds of the crane kind are to live and seek their food among the waters; but, having no web-feet, they cannot swim. To make up for this deficiency they are provided with long legs for wading, or long bills for groping, or both. This is compensation. Notice how every part of nature is occupied by appropriate inhabitants. Not only is the surface of deep waters peopled by numerous tribes of birds that swim, but marshes and shallow pools have almost as many tribes of birds that wade.

(4) In the structure of the common parrot's beak there is an inconvenience and a compensation for it. The inconvenience involves a dilemma that frequently occurs in the works of nature, namely that the peculiarity of structure that makes an organ fit for one purpose necessarily unfits it for some other purpose. The upper bill of the parrot is so much hooked, and so much overlaps the lower, that if (as in other birds) only the lower bill could move, the bird could scarcely gape wide enough to receive its food; yet this hook and overlapping of the bill could not be spared, for they form the instrument by which the bird climbs, and also breaks the nuts and other hard substances it feeds on. Nature has dealt with this problem by making the upper bill movable, as well as the lower. In most birds the upper bill is rigidly connected to the skull; but in the parrot it is joined to the skull by a strong membrane on each side of it, which raises and lowers it at pleasure.

(5) The spider's web is a compensating contrivance. The spider lives on flies, without wings to pursue them; a case (one would have thought) of great difficulty, yet provided for by a resource that no plan or effort of the spider could have produced if its external and internal structure had not been specifically adapted to the operation.

(6) In many species of insects the eye is fixed, and consequently with no power to turn the pupil towards the object. This great defect is perfectly compensated by a mechanism that we would not have suspected. The eye is a multiplying glass, with lenses looking in every direction and catching every object. Thus, although the orb of the eye is stationary, the field of vision is as wide as that of other animals. When this lattice-work was first observed, the number and smallness of the surfaces must have added to the surprise of the discovery. Adams tells us that 1400 of these little lenses have been counted in the two eyes of a drone-bee.

In other cases the compensation is achieved by the number and position of the eyes themselves. The spider has eight eyes, mounted on different parts of the head. They do not move, but by their situation they take in every view that the wants or safety of the animal make it necessary for it to take.

[Certain features of the **(7)** eye of the chameleon compensate for its inflexible neck; and a structural feature of the **(8)** intestine of the amphibious sea-fox compensates for the intestine's brevity.]

(9) The works of the Deity are known by expedients. Where we would look for absolute destitution—where we can find nothing but wants—some contrivance always comes in to make up for the privation. •A snail without wings, feet, or thread climbs the stalks of plants by the sole aid of a sticky liquid discharged from its skin. •A mussel, which might seem to lie helplessly at the mercy of every wave that went over it, has the singular power of spinning strong tendon-like threads by which it moors itself to rocks and timbers. •Whereas a cockle uses its stiff tongue to make for itself a shelter in the sand. •A lobster has in its constitution a difficulty so great that one could hardly guess how nature would deal with it. Because of the hardness of its shell, it cannot grow with the lobster (like the skins of most animals); and because the shell encases the lobster's limbs as well as its trunk, it cannot be enlarged by growth along its edge (like the shells of bivalves). How then was the growth of the lobster to be provided for? If a change of shell became necessary, how was the lobster to extricate himself from his present confinement? how was he to uncase his buckler or draw his legs out of his boots? At certain seasons the shell of the lobster grows soft, the animal swells its body, the seams open, and the claws burst at the joints. When the shell has thus become loose on the body, the lobster by a spasmodic motion casts it off. In this state, the liberated but defenceless fish retires into holes in the rock. The released body now suddenly pushes its growth, and in about 48 hours a new shell, is formed, adapted in every part to the increased dimensions of the animal. This wonderful change is repeated every year.

There are also compensations that extend over large classes of organisms, and to large portions of living nature.

(a) In quadrupeds, the deficiency of teeth is usually compensated by the faculty [see Glossary] of rumination. The tribe of sheep, deer and ox are without fore-teeth in the upper jaw; and they ruminate. The horse and ass are provided with teeth in the upper jaw, and do not ruminate. In the former class, the grass and hay descend into the stomach in almost the state in which they are cropped from the pasture. In the stomach they are softened by the gastric juice, which in these animals is unusually copious. Thus softened and tenderised, they are returned to the mouth, where the grinding teeth complete at their leisure the breakup that is necessary but was before left imperfect. The gastric fluid of sheep, for example, has no effect in digesting plants unless they have previously been chewed; but once vegetables are reduced to pieces by chewing, the fluid then exerts on them its specific operation.

(b) In birds the compensation is still more striking. They have no teeth at all. What have they then to make up for this severe lack? (I am speaking of turkeys, ducks, geese, pigeons and their like—grain-eating and plant-eating birds—for it is only concerning these that the question arises.) They are provided with a special and most powerful muscle, called the 'gizzard', whose inner coat is equipped with rough folds which by a strong friction against one another break and grind the hard food, as effectively as a coffee-mill would do, and by the same mechanical action. The gastric juice of these birds will not operate on the unbroken grain; so without the grinding action of the gizzard a chicken would starve on a heap of corn. A gizzard is not found in birds of prey; their food does not need to be ground down. The compensatory contrivance goes no further than the necessity.

(c) A very numerous and comprehensive tribe of terrestrial animals are entirely without feet; yet they move about, and do so quite swiftly. The lack of feet is compensated by the disposition of the muscles and fibres of the trunk. By means of the joint action of longitudinal and annular fibres—i.e. of strings and rings—the body of a reptile can be alternately shortened and lengthened, pulled in and stretched out. The result of this action is a progressive (and in some cases rapid) movement of the whole body in whatever direction the will of the animal sends it. The meanest creature is a collection of wonders. [He cites the mechanism by which an earthworm moves.] If we had never seen an animal move on the ground without feet, and we were set this problem:

> Given that an animal is capable of alternate contraction and relaxation, describe how it might be constructed so as to be able to move on the ground without feet;

something like the organisation of reptiles might have been hit on by the ingenuity of an artist; or it might have been exhibited in an automaton by the combination of springs, spiral wires, and ringlets. But surely the solution of the problem would be granted the praise of invention and of successful thought; there could be no doubt that intelligence had been employed in finding it.

17. Animate-to-inanimate relations

I have considered how the parts of an animal relate to other parts of the same animal, and how an animal relates to another individual of the same species. But we should also consider how the bodies of animals relate to the elements [see Glossary] by which they are surrounded. Some of these relations, grounded in the animals' constitution and properties, are close and important.

(1) Can it be doubted that the wings of birds have a relation to air, and the fins of fish to water? They are instruments of motion, suited to the properties of the medium in which the motion is to be performed; and these properties are different. Wasn't this difference contemplated when the instruments were differently constituted?

(2) The structure of the animal ear depends for its use on the specific nature of the fluid it is surrounded by. Not every fluid would serve. It has to be something whose particles repel one another, so that it forms an *elastic* medium; for it is by the successive pulses of such a medium that the undulations caused by the external body are carried to the organ, creating a communication between the object and the sense. If that is not done, the internal machinery of the ear, subtle though it is, cannot act at all.

(3) The organs of voice and respiration are indebted for the success of their operation—as much as the ear is—to the special qualities of the fluid the animal is immersed in. The structure of our organs and the properties of our atmosphere are made for one another. And it is the same relation whether you regard the organ as made for the element or (a less natural way of considering it) the element as prepared for the organ.

(4) But there is another fluid we have to consider. It has properties of its own, laws of acting and of being acted on totally different from those of air and water. I am talking about light. An organ is adapted, an instrument is correctly adjusted, to this new, this singular element—to qualities all its own and perfectly distinct and remote from the qualities of any other substance we know. The instrument is as much

a stand-out among the parts of the body,

•unique in in its form and in the substance it is composed of, and

•remote from the materials, the model, and the analogy of any other part of the animal frame,

as the element to which it relates is a stand-out among the substances we have dealings with. If this does not prove appropriation, what would prove it?

Yet the element of light and the organ of vision, however related in their office and use, have no connection whatever in their origins. The action of rays of light on the surfaces of animals has no tendency to breed eyes in their heads; and on the other hand the animal eye does not generate or emit light.

(5) Throughout the universe there is a wonderful proportioning of one thing to another. The size of animals (especially human animals) in relation to other animals and to the plants that grow around them is suited to their convenience. A giant or a pygmy could not have milked goats, reaped corn, mowed grass, ridden a horse, trained a vine, or shorn a sheep, or anyway not with the same bodily ease as we do. A pygmy would have been lost among rushes, or carried off by birds of prey.

(6) How close is the suitableness of the earth and sea to their various inhabitants; and of these inhabitants to their appointed places of residence!

Take the earth as it is; and consider the correspondence of the powers of its inhabitants with the properties and condition of the soil they tread. Take the inhabitants as they are; and consider the substances the earth yields for their use. They can scratch its surface, and its surface supplies all they want.

When we pass from land to water, we pass through a great change. But we are accompanied by a *corresponding* change in animal forms and functions, in animal capacities and wants. The earth in its nature is very different from the sea, but one accords with its inhabitants as exactly as the other.

(7) The last relation of this kind that I shall mention is the relation of *sleep* to *night*, which also appears to me to be a relation that was expressly intended. Two points are clear •the animal frame requires sleep, and •night brings with it a silence and cessation of activity that allows sleep to be taken without interruption. Animal existence is made up of action and slumber, and nature has provided a season for each. An animal that did not need rest would always live in daylight. A very active animal that needs to have its strength repaired by sleep has a constitution that fits with the returns of day and night. In the human species, for instance, if the bustle, labour and motion of life were upheld by the constant presence of light, sleep could not be enjoyed without being disturbed by noise and without time being spent on it that the sleeper would prefer to spend furthering his interests.

But night is not made solely (or even principally) for man. Inferior but less perverted natures taste its solace and expect its return with greater exactness and advantage than man does. I have often observed and admired the satisfaction and the regularity with which the greatest part of the irrational world yield to this soft necessity, this grateful vicissitude; how comfortably the birds of the air, for example, address themselves to the repose of the evening, and with what alertness they resume the activity of the day.

Nor does it disturb my argument that certain species of animals are active during the night and at rest in the day. With respect to them too there is a change of condition in the animal and an external change corresponding with it. There is still the relation, though inverted. In fact, the repose of other animals sets these at liberty, inviting them to their food or their sport.

If the relation of sleep to night (and in some instances its converse) is real, it is truly amazing. Day and night are things close to us; the change applies immediately to our sensations; of all the phenomena of nature, it is the most obvious and familiar to our experience; but in its cause it belongs to the great motions that are passing in the heavens. As the earth rotates around its axis, it ministers to the alternate necessities of the animals on its surface while at the same time obeying the influence of those **attractions** that regulate the order of many thousand worlds. The relation of sleep to night is the relation of the inhabitants of the earth •to the rotation of their globe; probably even •to the system that globe is a part of; and indeed •to the congregation of systems of which theirs is only one. If this account is true, it connects a chicken roosting on its perch with the spheres revolving in the firmament.

(8) If you reject the view that a central **attraction** explains the rotation of the earth on which the succession of day and night depends, I refer you to something that certainly does, namely the change of the seasons. Now, the constitution of animals given to torpor [= 'hibernation'] relates to winter in the way that sleep relates to night. As a defence against cold, and against the lack of food that the approach of winter induces, the Preserver of the world has provided migration for many animals and torpor in many others. As one example out of a thousand: if the bat did not sleep through the winter it would starve, as the moths and flying insects on which it feeds disappear. And the transition from summer to winter carries us into the very midst of physical astronomy, i.e. into the laws that govern the solar system at least, and probably all the heavenly bodies.

18. Instincts

I go immediately from relations to instincts, because I see them as a sort of relation. They are related to the animal's organisation because they combine with it to produce a joint effect. In many cases, instincts are strictly relations because they connect one animal with another animal.

An instinct is a propensity ·to act in a certain way· prior to experience and independent of instruction. We think that it is by instinct that the sexes of animals seek each other, that animals cherish their offspring, that the young quadruped is directed to the teat of its mother, that birds build their nests, and brood so patiently on their eggs; that insects which do not sit on their eggs deposit them in places where the young when hatched will find their appropriate food; that the salmon and some other fish go out of the sea into rivers to shed their spawn in fresh water.

The incubation of eggs

Take the incubation of eggs. I am sure that a couple of sparrows hatched in an incubator and kept separate from the rest of their species would proceed as other sparrows do in everything relating to the production and preservation of their brood. If that is right, the thing is inexplicable on any hypothesis except that of an *instinct* impressed on the constitution of the animal. What else could induce the female bird to prepare a nest before she lays her eggs? The fullness she might feel in a particular part of her body, from the growth and solidity of the egg, could not inform her that she was about to produce something which, when produced, was to be preserved and taken care of. Prior to experience, nothing led to this inference or to this suspicion. In every other instance, what issued from the body was rejected.

Again, how are birds to know that their eggs contain their young? Nothing in the appearance or in the internal composition of an egg could lead even the most daring imagination to conjecture that it was going to produce a living, perfect bird from under its shell. [He elaborates this point in great detail; then sums up:] It is hard to strip the mind of its experience. When familiarity has once put surprise to sleep, it is difficult to reawaken it. But if we could forget everything that we know (and that our sparrows never knew) about oviparous generation, divesting ourselves of all information except what we derived from reasoning on the appearances or qualities discovered in the objects presented to us, Harlequin coming out of an egg on the stage would not astonish a child more than the hatching of a chicken would and should astonish a philosopher.

Even supposing the sparrow somehow knew that within that egg the principle [see Glossary] of a future bird was concealed, from what chemist was she to learn that warmth was needed to bring it to maturity, or that the temperature of her own body was the degree of warmth required?

There is another case of oviparous economy that is even less likely to be the effect of education than it is in birds, namely that of moths and butterflies. They deposit their eggs in the precise substance—e.g. a cabbage—that will provide appropriate food not for the butterfly but for the caterpillar that will come from her egg. [He argues that the butterfly could not possibly have empirical evidence that this was the way to behave. The argument is perfectly convincing; but we hardly need it, and it is wearyingly long.]

Parental affection

But even if we could find a plausible origin for all the preparations that many unthinking animals make for their young, we would still have to account for the parental affection that is the source and foundation of these phenomena. This cannot be explained except as a matter of instinct.

For I don't think we shall want to explain the conduct of brutes towards their offspring in terms of •a sense of duty or of decency, •a care for reputation, or •compliance with public manners, with public laws, or with rules of life built on a long experience of their utility! And all attempts to account for the parental affection from association fail. With what is it associated? Most immediately with the throes of parturition, i.e. with pain and terror and disease. The more remote (but not less strong) association that which depends on *analogy*—·i.e. association with events that are somehow like this one·—is all against it. Everything else that comes from the body is cast away and rejected. In birds, is the egg what the hen loves? or is she kept on her nest by the expectation of a future progeny? What cause has she to expect delight from her progeny?

The salmon overcomes many obstacles in her progress up fresh rivers. And when she is there she sheds a spawn and immediately leaves it in order to return to the sea; and this output of her body she never afterwards recognizes in any shape whatever. Where shall we find a motive for her efforts and her perseverance? Shall we seek it in argumentation or in instinct?

When the butterfly lays her eggs in a place where the offspring caterpillar will find appropriate food, how shall we account for her conduct? I do not mean for her art and judgement in selecting and securing a maintenance for her young, but for the impulse on which she acts. What would induce her to exert any art or judgment or choice about the matter? The undisclosed grub, which she is destined not to know, can hardly be the object of a particular affection, if we deny the influence of instinct. So there is nothing left to her but something her nature seems incapable of, an abstract anxiety for the general preservation of the species, a kind of patriotism, a care that the butterfly race not become extinct.

The variety of resources, expedients, and materials that animals of the same species are said to have recourse to under different circumstances does not tell against the doctrine of instincts. What we want to account for is the propensity. Given that the propensity is there, it is probable enough that it will get the animal to act differently according to different exigencies. And this adaptation of resources may look like the effect of art and consideration, rather than of instinct, but still the propensity itself is instinctive. It is said that the woodpecker in Europe deposits her eggs in cavities that she scoops out in the trunks of soft or decayed trees, so that the eggs lie concealed from the eye and the hand of man; whereas in the forests of Guinea and the Brazils, which man seldom frequents, the woodpecker hangs her nest to the twigs of tall trees, thereby placing them out of the reach of monkeys and snakes. Suppose this is true, and is adduced as evidence of a reasoning and distinguishing precaution on the part of the bird that builds these nests, still the question returns: why is there a propensity to build at all?

Explaining instinct by sensation

I know about the theory—I shall call it ‘the Hypothesis’—that resolves instinct into sensation, asserting that

> what appears to have a view and relation to the •future is only the result of the •present disposition of the animal’s body and of pleasure or pain experienced at the time.

Thus the incubation of eggs is accounted for by the pleasure the bird is supposed to get from the pressure of the smooth convex surface of the shells against the abdomen, or by the relief the egg’s mild temperature may provide for the heat of the lower part of the body (which is observed to be greater than usual at this time). This present gratification is the only thing that keeps the hen sitting on her nest, and so far as she is concerned the hatching of the chickens is an accidental consequence. Similarly, the affection of viviparous animals for their young is explained by the relief—perhaps even the pleasure—they get from giving suck. The young animal’s seeking its mother’s teat is explained by its sense of smell, which is attracted by the odour of milk. The salmon’s forcing its way up the stream of fresh-water rivers is attributed to some gratification or refreshment she receives from the change of element in this particular state of her body.

Two main things should be said about the Hypothesis.

(i) Of the cases requiring solution, there are few it can be applied to with tolerable probability, and none it can be applied to without strong objections based on the circumstances of the case. The cow’s attention to its calf and the ewe's to its lamb seem to be prior to their sucking. The attraction of the calf or lamb to the mother's teat is not explained by simply referring it to the sense of smell. What made the scent of milk so agreeable to the lamb that it follows with its nose or seeks with its mouth the place it comes from? No observation, experience or argument could *teach* the newborn animal that the source of the scent was food. And none of the animals that are not designed for that nourishment ever try to suck or to seek out any such food. We can only conclude that the parts of animals related to suckling are fitted for their use, and constructed with knowledge of that use.

(ii) Even in the cases where the Hypothesis looks strongest, it does not *at all* weaken the argument for intention and design. The doctrine of instincts is that of appetencies [see Glossary] added to an animal's constitution to achieve a purpose beneficial to the species. The Hypothesis derives these appetencies from organisation; but then this organisation is just as specifically, precisely, and therefore evidently adapted to the same ends as the appetencies ·or instincts· themselves would be according to the old way of looking at things. According to the Hypothesis, sensation takes the place of foresight, but this ·sensation· is the effect of contrivance on the part of the Creator. Suppose that the hen *is* induced to brood on her eggs by the enjoyment she experiences from the pressure of round smooth surfaces or the application of a temperate warmth. How does it come about that this itching or whatever that is supposed to cause the bird's inclination is felt at exactly the time when the inclination itself is needed, when it tallies so exactly with the internal constitution of the egg and with the help that constitution requires in order to bring the egg to maturity? In my opinion, if we accepted this solution it should *increase* our admiration of the contrivance. A gardener lighting up his stoves exactly when he wants to force his fruit, and when his trees require the heat, does not give a more certain evidence of design.

Again, when a male and female sparrow come together, they do not meet to confer on the expediency of perpetuating their species. As an abstract proposition, they don't care a whit whether their species is perpetuated! They follow their sensations; and this results in all the consequences that the wisest counsels could have dictated, that could have been produced by the most solicitous care for futurity, the most anxious concern for the sparrow-world. But how do these consequences ensue?

- The sensations and the constitution they depend on are as plainly directed to the purpose we see fulfilled by them,
- the series of intermediate effects are as manifestly planned with a view to that purpose, i.e.
- *design* is as completely displayed by the phenomena,

as would be the case if the operations were begun or carried on by what some ·of us· regard as the only things properly called 'instincts', namely desires directed to a future end and having no accomplishment or gratification distinct from the attainment of that end.

In short, I say to the patrons of the Hypothesis: So be it, that the actions of animals that we refer to instinct are not performed with any view to their consequences, but are attended in the animal with a present gratification and are pursued for the sake of that gratification alone; what does all this prove but that the foresight, which must be somewhere, is not in the animal but in the Creator?

[Paley adds a paragraph about the intensity of parental affection in animals, and about how much this sometimes costs the parents, especially the mothers.]

One observation more, and I will dismiss the subject. The pairing of birds, and the non-pairing of beasts, forms a distinction between the two classes, which shows that the conjugal instinct is varied according to the needs of the offspring. In quadrupeds, the young animal draws its nourishment from the body of the mother. The male parent does not—*cannot*—contribute anything to its maintenance. In the winged race, the young bird is nourished by food that requires the industry [see Glossary] of both parents to procure and bring it home in a large enough quantity for the demands of a numerous brood. In this difference we see a reason for the vagrant instinct of the quadruped, and for the faithful love of the feathered mate.

19. Insects

[In this chapter Paley 'collects into a chapter by themselves' some examples of contrivance in insects that he 'could not properly introduce under any of the headings' of previous chapters; and inserts a diversion concerning animals with shells. This 'collection' of hard-to-classify material is omitted from the present version.]

20. Plants

I think a designed and studied mechanism to be, in general, more evident in animals than in plants; and there is no need to dwell on a weaker argument where a stronger is at hand. But a few observations on the vegetable kingdom lie so directly in my path that it would be improper to pass by them without notice. [At the risk of 'impropriety', the present version omits this 'weaker argument'.]

21. The elements

When we come to the elements [see Glossary] we take leave of mechanics, because we come to things of whose organisation (if indeed they are organised) we are admittedly ignorant; in fact, our investigations reach a dead-end long before we arrive at the elements. But then it is for our comfort to find that a knowledge of their constitution is not necessary for us. For instance, as Addison has well observed,

> 'We know water sufficiently when we know how to boil, how to freeze, how to evaporate, how to make it fresh, how to make it run or spout out in whatever quantity and direction we please, without knowing what water is.'

This observation is even more proper now than it was when it was made; for the constitution and constituent parts of water seem in some measure to have been recently discovered, yet apparently we can make no better or greater use of water since the discovery than we did before it.

We can never think of the elements without reflecting on how many uses one substance can have. The **air** supplies the lungs, supports fire, conveys sound, reflects light, diffuses smells, gives rain, wafts ships, bears up birds. **Water**, besides maintaining its own inhabitants, is the universal nourisher of plants, and through them of terrestrial animals; is the basis of their juices and fluids; dilutes their food; quenches their thirst, floats their burdens. **Fire** warms, dissolves and illuminates, and is the great promoter of vegetation and life, if not necessary to the support of both.

I could go on almost as long as I pleased on each of these uses, but it seems to me that I hardly need to do more than state them. But here are a few remarks that I judge it necessary to add.

(1) Air is essentially different from earth. There appears to be no necessity for an atmosphere's investing our globe; yet it does invest it, and we see how many, various, and important are the purposes it serves for every order of animated beings on the terrestrial surface.

If I could see only by means of rays coming directly from the sun, whenever I turned my back on the sun I would find myself in darkness. If I could see by reflected light, but only light reflected from solid masses, these masses would shine and glisten, but it would be in the dark. What enables the world to be illuminated in the way it *is* is the light of the sun coming to the eye from all sides and in every direction, reflected by the numerous, thickly scattered, widely diffused particles of the air.

That function of the air needed a little explaining. Each of its other uses will be understood on the first mention of it.

The atmosphere has the power to evaporate fluids, and the adjustment of this power to our needs is seen in its action on the sea. Water and salt are intimately mixed together in the sea, yet the atmosphere raises the water and leaves the salt. Pure and fresh raindrops have been collected from brine!

By evaporation water is carried up into the air; by the reverse process it falls down on the earth. And how does it fall? Not by the clouds being all at once re-converted into water, and descending like a sheet; not by rushing down in columns from a spout; but in moderate drops, as from a colander.

Air is made unfit for the support of animal life by respiration, flame and putrefaction. By the constant operation of these corrupting principles, the whole atmosphere would eventually come to be deprived of its needed degree of purity, if there were no restoring causes. Some of these causes seem to have been discovered. •Vegetation proves to be one of them: a sprig of mint, corked up with a small portion of foul air placed in the light, makes it again capable of supporting life or flame. So here is a constant circulation of benefits between the two great provinces of organised nature: the plant purifies what the animal has poisoned; in return, the contaminated air is more than ordinarily nutritious to the plant. •Agitation with water turns out to be another of these restoratives. The foulest air, shaken in a bottle with water for long enough, recovers much of its purity. The waves in a storm at sea are doing the very thing that was done in the bottle. So it ought to reconcile us to these agitations of the elements whose consequences we sometimes deplore, to know that they tend powerfully to restore to the air the purity that so many causes are constantly impairing.

(2) Water is admirable for the negative qualities that constitute its purity. [He recites some of the drawbacks if water as such had a taste, summing up:] Having no taste of its own, it becomes the sincere vehicle of every other liquid.

Equally admirable is the constant round that water travels, by which—without spoiling or wastage—it continually offers itself to the wants of the habitable globe. From the sea are exhaled the vapours that form the clouds; these clouds descend in showers that penetrate the crevices of the hills and fill springs; the springs flow in little streams into the valleys where they unite and become rivers, which then feed back into the ocean. So there is an incessant circulation of the same fluid, and probably not one drop more or less now than there was at the creation.

(3) I said above that 'fire dissolves'. This probably gave you only the thought of fire melting metals, resins, and some other substances, fluxing ores, running glass, and helping us in many of our chemical or culinary operations. But these are only intermittent uses, and provide a very imperfect [see Glossary] notion of what fire does for us. The great office of fire in the economy of nature is keeping things in a state of solution, i.e. in a state of fluidity. If it were not for the presence of a certain degree of heat, all fluids would be frozen. The ocean itself would be a quarry of ice; universal nature stiff and dead.

So we see that the elements have a strict relation not only to the constitution of organised bodies but also to each other. Water could not perform its office to the earth without air; nor exist as water without fire.

(4) Whether we regard light as of the same substance as fire or a different substance, its *usefulness* to us is undisputed. The observations I shall offer will concern the little that we seem to know of its constitution.

Light passes from the sun to the earth in eleven minutes,[1] a distance that it would take a cannon ball 25 years to cover. Nothing more need be said to show the velocity of light. Urged by such a velocity, with what force must its particles drive against every substance, animate or inanimate, that stands in its way! This might seem to be a force sufficient to shatter to atoms the hardest bodies, let alone that tenderest of animal substances, the eye.

This is guarded against by a corresponding minuteness of the particles of which light is composed. The human mind cannot imagine anything as small as a particle of light, but this smallness is easy to prove. A drop of tallow expended in the wick of a farthing candle will send forth rays sufficient to *fill* a hemisphere of a mile diameter, so that an aperture the size of the pupil of an eye, wherever it is placed within the hemisphere, will be sure to receive some of them. We cannot estimate what floods of light are continually poured from the sun, but we can compute the immensity of the sphere with the sun at its centre and the orbit of the earth on its perimeter; and we have evidence that throughout this whole region the particles of light lie, in latitude at least, near to one another. The density of the sun's rays at the earth is such that the number falling on a burning-glass of an inch diameter is sufficient, when concentrated, to set wood on fire.

The thinness and the velocity of particles of light, as ascertained by separate observations, may be said to be proportioned to each other; both surpassing our utmost stretch of comprehension, but *proportioned*; and it is just this proportion that converts a fearsome element into a welcome visitor.

22. Astronomy

I have never thought that astronomy is the best medium through which to prove the agency of an intelligent Creator; but once this has been proved, astronomy shows beyond all other sciences the magnificence of the Creator's operations. It raises the already-convinced mind to sublimer views of the Deity than any other subject provides; but it is not as well adapted to the purpose of *argument* as some other subjects are. We have no way to examine the constitution of the heavenly bodies. The very simplicity of their appearance is against them: we see only bright points, luminous circles, or the phases of spheres reflecting the light that falls on them. Now, we deduce design from relation, aptitude, and correspondence of *parts*, so some degree of complexity is necessary for a subject to be fit for this sort of argument. But the heavenly bodies (except perhaps for Saturn's ring) do not present themselves to our observation as compounded of parts at all. This may be a perfection in them, but it is a

[1] [Actually, a little over eight minutes.]

disadvantage to us as inquirers into their nature. They do not come within reach of our mechanics.

And what I say of their forms is true also of their motions. Their motions are carried on without any perceptible intermediate apparatus, which cuts us off from one principal ground of argumentation and analogy. We have nothing to compare them with; no invention, discovery, operation or resource of art that in this respect resembles them. Even things that are made to imitate and represent them—such as planetaria and celestial globes—have no affinity to them in the cause and principle [see Glossary] by which their motions are actuated. I can assign a reason of utility to explain why, though the action of terrestrial bodies on each other is nearly always through the intervention of solid or fluid substances, central attraction does not operate in this manner. The intervals between the planetary orbs had to be devoid of any inert matter, fluid or solid, because such an intervening substance would by its resistance destroy the very motions that attraction is employed to preserve. This may be a final cause of the difference; but still the difference destroys the analogy.

Actually, what is really wonderful is how much understanding of astronomy we *do* have. A diminutive animal on the surface of one of the planets—a little, busy, inquisitive creature—has been able to observe the whole system of worlds to which its own world belongs; and to note the changes of place of the immense globes that compose it, and very precisely mark out beforehand the location in the heavens they will be found to have at any future moment. And it has done this by the use of senses given to it for its domestic necessities, and of telescopes that it has had the skill to produce. All this is wonderful, whether we aim our admiration at the constancy of the heavenly motions themselves or at the perspicacity and precision with which mankind has noticed them. And this is not even the chief part of what astronomy teaches. By bringing acutest reasoning to bear on the exactest observation, the astronomer has been able, out of the confusion (for such it is) under which the motions of the heavenly bodies present themselves to the eye of a mere sky-watcher, to work out their order and their real paths.

So our knowledge of astronomy is admirable, though imperfect [see Glossary]; and among the admitted factors that hamper our investigation of the Deity's wisdom in these the grandest of his works, we find in the phenomena circumstances and laws that are sufficient to indicate an intellectual agency in three of its principal operations—

- *choosing*, out of a boundless variety of equally possible suppositions, the one that is beneficial;
- *determining* that convenience would come from something with a thousand-to-one probability of not being convenient, and
- *regulating* the quantity and degree of things which by their nature were unlimited with respect to both.

I shall offer a few instances under each of these headings, selecting ones that best admit of informal explanation. [You'll see that Paley does not strictly organise the rest of this chapter 'under these headings'.]

(ia) Among proofs of choice, one is the fixing of the source of light and heat in the centre of the ·solar· system. The sun is afire and luminous; the planets that move around it are cold and dark. There seems to be no antecedent necessity for this order. Nothing in the nature of the heavenly bodies requires the stationary ones to be on fire and the moving ones to be cold. So when we consider that the sun is *one* and its planets are at least *seven*, and that it is indifferent to their nature •which are luminous and which are opaque and •what order they are in with respect to each other, we can judge how unlikely it is that the present arrangement took place by chance.

Some of those who reject an intelligent Creator guess that the planets themselves are cooled or cooling masses that were once thousands of times hotter than red hot iron, as the sun is. And they usually contend that the planets are masses of matter that were originally struck off from the body of the sun by the impact of a comet, or by a shock from some other cause that we don't know. If these erstwhile parts of the sun have in process of time lost their heat, the sun itself must also lose its heat in due course and therefore be incapable of an eternal duration in the state in which we see it.

I take it to be obvious that the actual mode of distributing luminous and opaque bodies is preferable to any other. It requires more astronomy than I can lay before you to show in detail what would be the effect on the system of a dark body at the centre and of one of the planets being luminous; but I don't think that diagrams or calculations are required to make it clear that •the ignited planet would not be sufficient to illuminate and warm the rest of the system, and that •its light and heat would be imparted to the other planets much more irregularly than light and heat are now received from the sun. (The former point assumes that the revolving bodies would have to be smaller than the central one.)

(ib) Another thing in which a choice appears to be exercised, and where wrong possible choices infinitely outnumbered right ones, is what geometricians call the axis of rotation. I shall try to explain. The earth is not an exact globe but an oblate spheroid, something like an orange. Now the ·possible· axes of rotation are as many as can be drawn through the centre to opposite points on the surface; but of these axes none are permanent except either •its *one* shortest diameter, i.e. the one that passes through the heart of the orange from the place where the stalk is inserted into it, or •its *many* longest diameters, all at right angles with the shortest one and all ending at the circumference that goes around the thickest part of the orange. The shortest diameter is that on which in fact the earth turns, and it is a permanent axis. If the earth had been set spinning by blind chance, a casual impulse, a random stroke or push, the odds were infinite that it would have been spun on a wrong axis. When a spheroid in rotatory motion gets on a permanent axis, it keeps there, its poles preserving their direction with respect to the plane and to the centre of its orbit. But when it turns on an impermanent axis, it is always liable to vacillate from one axis to another, with a corresponding change in the inclination of its poles. The effect of this unfixedness would be that the equatorial parts of the earth might become the polar, or the polar the equatorial; to the utter destruction of plants and animals, which cannot interchange their situations but are respectively adapted to their own. The habitable earth and its beautiful variety might have been destroyed by a simple mischance in the axis of rotation.

(ic) By virtue of the simplest law that can be imagined, namely that

> a body in motion continues in the line in which it was proceeding, and with the same velocity, unless there is some cause for change,

it comes about that cases arise in which attraction, incessantly drawing a body towards a centre, never brings it to that centre but keeps it in eternal circulation around it. If it were possible to fire off a cannon-ball with a velocity of five miles per second, and the resistance of the air could be taken away, the cannon-ball would for ever wheel round the earth instead of falling down on it. This is the principle that sustains the heavenly motions. The Deity, having appointed this law to matter, has turned it to a wonderful account in constructing planetary systems.

The actuating cause in these systems is an attraction that varies inversely with the square of the distance; that is, at twice the distance it has a quarter of the force; at half the distance it has four times the strength, and so on. Now, concerning this law of variation three things should said.

First , for all we know to the contrary, attraction was just as susceptible of one law as of another. It might have

- •been the same at all distances,
- •increased as the distance increased,
- •diminished with the increase of the distance, but in ·any one of· ten thousand different proportions from the actual one, or
- •followed no stated law at all.

If attraction is what many Newtonians thought it to be, a primordial property of matter—not dependent on or traceable to any other material cause—then by the very nature and definition of a primordial property it was indifferent to all laws. If attraction is caused by something immaterial, then again for all we know to the contrary it was indifferent to all laws.

There is an account of attraction that seems to assign to it the law that we find it to observe, making it a law not of choice but of necessity. This account ascribes attraction to an emanation from the attracting body. It is probable that the influence of such an emanation will be proportioned to the density of the rays of which it is composed, and this will vary inversely with the square of the distance. I do not question the mathematics of this solution, but I do question whether there is any sufficient reason to believe that attraction is produced by an emanation. For my part, I am totally at a loss to comprehend how particles streaming *from* a centre should draw a body *towards* it. [He adds further reasons for scepticism about this theory, and concludes:] Except this one point about the variation of the attracting force at different distances agreeing with the variation of the density, there is nothing whatever to support the hypothesis of an emanation and—it seems to me—almost insuperable reasons against it.

Secondly, while the possible laws of variation were infinite, the laws compatible with the preservation of the ·solar· system lie within narrow limits. If the attracting force had varied according to *any* direct ·as against inverse· law of the distance, great destruction and confusion would have ensued. If the large and remote planet Saturn had attracted the earth in proportion to the quantity of matter contained in it (which it does) and also in any proportion to its distance, it would have dragged our globe out of its course and have perplexed its motions to a degree incompatible with our security, our enjoyments, and probably our existence. Of the inverse laws, if the centripetal force had changed as the *cube* of the distance or in any higher proportion, the consequence would have been that once the planets began to approach the sun they would have fallen into it; if they once increased their distance from the centre (though by ever so little), they would for ever have receded from it. Thus, the laws of attraction by which a system of revolving bodies could be maintained in their motions lie within narrow limits, compared with the possible laws.

Thirdly, out of the different laws that lie within the limits of admissible laws, the best is chosen; there are advantages in this particular law that cannot be demonstrated to belong to any other law, and some of them can be demonstrated not to belong to any other. [Paley tries to make good on this with several dauntingly obscure pages arguing that various good aspects of our situation depend on matter's being subject to, precisely, the inverse square-of-the-distance law. Then:]

To conclude: In astronomy the great thing is to raise the imagination to the subject, often in opposition to the impression made on the senses. For example, the distance at which we view the heavenly bodies creates an illusion that they move slowly. The moon takes some hours to get half a yard from a star that it touched, and we may think that a motion so deliberate is easily guided. But in fact the moon is driving through the heavens at considerably more than 2,000 miles an hour; which is more than double the speed which a ball is shot from the mouth of a cannon. Yet this prodigious speed is as much under government as if the planet were conducted in its course inch by inch. It is also difficult to bring the imagination to conceive (as we must if we are to judge tolerably of the matter) how loose, so to speak, the heavenly bodies are. Enormous globes, held by nothing, confined by nothing, are set into free and boundless space, each to seek its course by the virtue of an invisible principle [see Glossary]; a single principle, the same in all; and ascertainable. To

- •preserve such bodies from being lost, from running together in heaps, from distracting one another's motions in a degree inconsistent with any continuing order; that is. to
- •cause them to form planetary systems that can be upheld, and are accommodated to the organised and sensitive natures that inhabit the planets, or at least our earth;

all this requires an intelligent interposition, because it requires an adjustment of force, distance, direction, and velocity that chance could not have produced. In the way it serves our utility, this adjustment is similar to what we see in ten thousand subjects of nature that are nearer to us, but it is stupendous in its power and in the extent of space through which that power is exerted.

Many of the heavenly bodies, such as the sun and fixed stars, are stationary. Their immobility must result from an absence of attractions or from an equilibrium of them; and it shows that a projectile impulse was originally given to some heavenly bodies and not to others. Also, if attraction acts at all distances, there can only be one immobile centre of gravity in the universe, and all bodies whatever must be •approaching this centre or •revolving round it. According to the first of these suppositions, if the duration of the world had been long enough, all the great bodies of which it is composed must have gathered together in a heap around this central point. But no changes have been observed that give us the smallest reason for believing that either the one (all-in-a-heap) supposition or the other (all revolving) is true. So we should conclude that attraction itself is controlled or suspended by a superior agent; that there is a power above the highest of the powers of material nature; a will that restrains and circumscribes the operations of everything.[1]

[1] Many astronomers deny that any of the heavenly bodies are absolutely stationary. Some of the brightest fixed stars certainly have small motions; and of the rest the distance is too great and the intervals of our observation too short for us to know for sure that they don't have the same. By a comparison of the motions of the fixed stars that have been observed, a motion of our system is supposed to be discovered. By continuing this analogy to all systems, it is possible to suppose that attraction is unlimited, and that the whole material universe is revolving round some fixed point within its containing sphere of space.