them *post mortem*, and found that after all it was not a case of gumma. But I suppose that in every rapidly-growing tumour there is around it a considerable quantity of freshly-formed new tissue which is amenable to the influence of such drugs as iodide of potassium and mercury. So we must not be misled into giving a favourable prognosis when we happen to see the symptoms very much reduced by the administration of iodide of potassium and mercury.

Then with regard to the recovery after operation. It is curious how the results in this respect have varied in this hospital from time to time. In some periods one has been far from sanguine as to the favourable results of operation in tumour cases. At other times the brilliant results of surgical interference have been most encouraging. And there is no doubt, I think, that if the tumour can be removed, and if it is one of those tumours which has been exerting its influence by pressure, rather than by infiltration, the outlook is extremely good, even when the pressure which has been exerted has been excessively great. And the fact that such a result follows operation in certain cases, and the fact that you never can be quite sure whether a tumour is infiltrating or whether it is one which is growing into the nervous tissues from the outside, seems to necessitate a resort to operation in many cases. No doubt in some of the cases which we have had here the results have been extremely gratifying, and have been far better than one would have dreamed of. It is true that in other cases the results have been most discouraging, but it seems to me that as the condition is one of intracranial growth in which the outlook without operation must be exceedingly poor, that one would be justified in stretching a point in order to give the patient the possible benefit which surgery might have to give. Of course, with regard to the influence of iodide of potassium and mercury, there cannot be two opinions in reference to their efficacy in most syphilitic growths and also in some non-syphilitic ones. A considerable fallacy exists with reference to the influence of those drugs in the case of intracranial tumour, because the effects which those drugs may have in the cases which are not syphilitic may lead to the idea that they are syphilitic. So the treatment of intracranial tumours resolves itself into two points. First of all, the administration of iodide and mercury in every case, whether there is a syphilitic history or not, and the administration of some drug like iodide of iron, which is supposed to influence tuberculous growths. The second point is the treatment by surgery, and wherever the treatment by drugs seems inefficacious, unless there is some strong indication to the contrary, which I can scarcely conceive, I think we should give the patient the benefit of an exploratory operation. Of course in many cases it is found after exploration that the tumour is of such a character that it cannot be removed, but in such a case the condition of the patient is not worse than it was before, and the chances are that he is relieved of his headache and vomiting, and possibly also his optic neuritis may subside as a result of the operative measure.

An Address

ON THE

CRYSTALLINE LENS IN HEALTH AND IN CATARACT.

Delivered before the Post-Graduate Class in Ophthalmology in the University of Oxford, July 10th, 1905.

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GENTLEMEN,—If and when the complete history of ophthalmology is well and truly writ, I trust that due mention will be made of, and due credit will be ascribed to, the life and labours of Alhazen, the Saracen. He flourished in the eleventh century of our era, and died at Cairo in 1038. He was, alike in theory and practice, a man in advance of his time, and perhaps was more successful with his theories than with his practice. It is true he failed in his undertaking to dam the Nile, a work the completion of which it has been reserved for this generation to witness. He, however, seems to have been the first to explain that vision was due, not to some emissive property or tentacular agency on the part of the

eyes, but to the refractive influence of their translucent media and to sensory impressions made upon the retinae. He also demonstrated atmospheric reflection and refraction, thus accounting for the phenomena of twilight and of the apparent reduction of size of heavenly bodies as they pass from the horizon towards the zenith. Before Alhazen's time the rôle of the crystalline lens was incomprehensible and mysterious. It had been sanctified by the ancients as the seat, or one of the seats, of the soul or *πνεῦμα*, while other old authorities had deemed it to be the organ of vision; just as the vulgar to-day will sometimes bring the extruded lens from a case of perforative ulceration of the cornea and tell you the child's "sight" has come out.

It is not surprising that a structure so beautiful and so unique in the animal economy as the lens should, even in these prosaic times, excite our thoughtful scrutiny, and we do but find our interest stimulated and fascinated as we proceed to investigate the development, the structure, the function, and even the defects and diseases of this dioptric jewel of the globe.

I need not tell you that no amount of condensation will enable me to crowd into the limits of a single lecture even a *résumé* of the work that has been accomplished in this department of ophthalmology; the lecturer and the subject of the lecture being alike the selection of your excellent Reader, Mr. Doyné, I am absolved of responsibility, while the amplitude of the title will enable me to dwell on such topics as I have paid special attention to while passing lightly over such matters as you will find adequately dealt with in the ordinary textbooks.

The crystalline lens, in almost every aspect in which we approach it as an object of study, presents features which, if not unique, are almost without parallel in other structures of the body. Take, for example, its persistent growth from infancy to age; its complete isolation from blood supply, coupled with its most perfect nutrition by endosmotic and exosmotic currents; its elasticity so perfectly controlled by muscular action as to subserve faithfully the purposes of the most delicate of our senses; while its pellucidity, which is shared by the other dioptric media, is, in its case, accompanied and sustained by a construction so complex, and a mode of growth so involved, that there are some points in relation to both which have not yet been thoroughly elucidated.

The rôle of the lens in disease has afforded no less occasion for wonder, mystery, and disputation. By a curious inversion of order, successful treatment of cataract appears to have preceded any accurate knowledge of its cause. It would almost seem either that a traditional treatment had survived the knowledge on which it was originally based, or that a pre-established harmony had guided the hand of the empiric.

Thus, Albucasis the Moor, a skilful surgeon of Cordova in the eleventh and twelfth centuries, has a chapter on the cure of cataract by depression, and, in a fine reproduction of his works in Arabic and Latin, edited by Channing at Oxford in 1778, you will find a neat representation of the instrument he employed. Yet he speaks "*de cura aquae quae descendit in oculo vel cataracta*." Pliny and Galen seem to have been acquainted with "couching." The term cataract appears to have been employed by the School of Salerno, derived from the Greek *καταρράγνυμι*, but whether used metaphorically, as in the quotation I gave from Albucasis, or in the sense of "breaking down" or "confusing" is not clear. The older Greek writers had called it *ὑποχυσίς ὄφθου*, the Latins "suffusio," and the Arabo-barbarians, "gutta in oculo," all terms borrowed from humoral pathology. How, indeed, was any rational pathology then possible?

However, since Helmholtz presented us with the ophthalmoscope, about the middle of last century, much mystery has been cleared away. Amaurosis, that invention of the schoolmen which connoted a condition of the eye in which neither the patient nor the oculist could see anything, has been resolved, and the parts played by the lenticular and the deeper structures of the globe respectively in its production have been correctly apportioned, while the old confusion between glaucoma and cataract has been for ever set at rest.

M. Brisseau, of Tournai, appears to have been the first to explain correctly the true nature of cataract. A soldier with cataract having died in the Tournai Hospital in 1705, he examined the eyes *post mortem*; he thereupon made the startling discovery that a cataract was nothing but an opaque lens, and not a membrane engendered in the aqueous. Much elated, he reported his secret to Duverney, who would not

hear of it, and advised Brisseau not to endanger his reputation by publishing so ridiculous a proposition; moreover, the iconoclastic Brisseau was given to understand that his discovery might occasion offence to some members of the Academy who had written on optics.

Such are the perils that await the reformer, even in matters of science, when authority is at variance with the facts. The sequel is not un instructive; poor Brisseau published his thesis, and he was thereupon informed, not that he was wrong, but that it was no discovery after all, in fact, that he had been anticipated by other observers some forty years previously. How true is the observation that a test of truth is its capacity for re-discovery.

Even nowadays the term "cataract," which may be used as synonymous with any departure from pellucidity of the lens or its capsule, is still received by the laity with scarcely less awe and foreboding than are those other terms of terror commencing with the same initial, "consumption," and "cancer." Happily, with our modern methods of ophthalmic surgery we are able authoritatively to assuage such terror as often groundless. The lens, even in its opacity, is again unique in this fact, that, having ceased to be useful, it can very well be done without, and that, after its successful extraction, almost perfect sight may be restored, and that, too, without the long period of waiting in twilight which was once the pitiable lot of the cataractous.

Just as von Baer has taught us that the embryological history of the higher organisms repeats, as in epitome, the evolutionary history of the race, so in the case of an individual and highly differentiated organ like the human eye, as we trace its building up in the embryo, we pass—though it may be rapidly—in review some of the stages which are recognized as final in the lower animals; and the story is again true as we study in detail the embryological history and comparative anatomy of its component parts.

Whether we turn our attention to the rudimentary eyes of the leech, or the starfish, or to the multitude of eye dots which are scattered over the surface of some of the marine slugs such as *Onchidium*, or, on the other hand, investigate the compound eyes of insects and crustaceans, or the refractive eyes of cephalopods and vertebrates, we find three elements, all owning an epiblastic origin, early co-operating in promoting some influence or impression by the outside world upon the nervous system of the individual. These three elements are—(1) nerve fibre; (2) pigment cells; (3) a crystalline medium.

How the collocation of these three elements, perhaps at first fortuitous, then subserving some humble function (possibly nutritive in its nature), later on evolves, by gradual steps, into an elaborate optical camera for conveying visual impressions is a problem upon which we may speculate at pleasure. We know that animal pigment, like chlorophyll in plants, not improbably plays an important part in facilitating absorption of chemical energy from the sun. Any collection or concentration of light by a crystalline structure overlying such pigment would of course facilitate this "heliophagic" (sun-eating) process; while the stimulation of a subjacent nerve by the solar energy, and the withdrawal of such stimulus by the intervention of opaque bodies would awaken a sense of externality, excite muscular action, and lead to locomotion. It has been found that *Meduse* will collect around a ray of sunlight in a darkened jar, not, presumably, because they see it, but because they eat it and gain energy from it. It is possible, then, that association of nerve, pigment, and refracting cell, all modified ectoderm, may have evolved through a heliophagic stage, and thence onward into an agency for the appreciation of light from darkness, thus giving a sense of environment more delicate than the tactile, and finally, by progressive differentiation and integration, the most delicate of the organs of special sense may have been progressively built up.

It is, however, in contemplating the progressive development of organs of such complexity and adaptation as the human eye that the insufficiency of natural selection as explanatory of the whole process is most apparent. The action and reaction of structure and function is so intimate, a slight morphological change affording some distinct dynamic advantage, or *per contra* some habitual physiological action effecting some desirable modification of structure, that we may find it hard to decide which takes the initiative and which is the resultant. Indeed, whether any highly evolved organ or organism be but the heir of all the ages and survivor of the fittest as the result of mere natural selection, or, on the other hand, expresses the formulation of some increasing purpose,

must be decided in accord with our particular metaphysical conceptions, but of the reality of the evolutionary process, alike in organ and in organism, there seems no room for doubt.

DEVELOPMENT.

While dealing with these general considerations it is interesting to reflect that the lens, as its alternative name reminds us, betrays an affinity with the bodies classed as crystals. Its formation and upbuilding, with geometric precision, around tri-radial or multi-radial polar axes is reminiscent of the deposition of a crystal from solution, and although it is true the analogy must not be pressed too far, it is interesting and instructive to recall this striking link in the chemico-biological chain.

In following out the life-history of the lens it is well ever to bear in mind its derivation from the ectoderm, and to remember that it continues to own allegiance to cuticular tendencies even when it has entered upon an independent career in a new situation. It is also necessary to bear in mind that at an early period of fetal life this lens vesicle or follicle, when no longer pedunculated to the ectoderm, gets surrounded with a vascular envelope of mesoblastic derivation. This vascular invagination takes place through a cleft in the secondary optic cup at its lower and inner portion, and default in later closure of this cleft we know as coloboma of the iris or of the choroid, or of both. On the other hand, the plication of this vascular sheath gives rise to the pecten of birds and the falciform fold in the eyes of fishes.

A yet more proximate influence upon the early nutrition and development of the lens is effected by a most interesting and usually evanescent structure, also of mesoblastic origin, namely, the capsulo-pupillary membrane. In 1887, in the *Moorefields Hospital Reports*, I published a case, with a picture, of the persistence of a portion of this membrane, and in the following year, in another paper on the capsulo-pupillary membrane, I showed how the failure to clear away some or other of the parts of this fetal scaffolding may give rise to certain vestigial anomalies and defects, and certain non-pathological cataracts (as I have called them), the occurrence of which needs to be borne in mind in diagnosing the nature and causation of some of the anomalies encountered in or around the lens.

It is important to remember that the iris is a relatively late outgrowth from the choroid, and that in early fetal life the vascular envelope of the lens plays a very important part not only in nourishing the crystalline, but also in upbuilding the structures surrounding it.

Posteriorly this sheath extends into and indents the optic nerve, whose central artery is continued into it and through it to the posterior pole of the lens. Equatorially the lens capsule (if not itself derived from this sheath) is reefed into place by cordage connecting it with the ciliary processes, while anteriorly this sheath occupies the place which is destined to become the aqueous chamber.

As the iris develops and advances centripetally it comes into contact with this capsulo-pupillary sheath. Anastomosis appears to take place between their vessels along a circle which is later known as the corona iridis about a quarter or one-fifth of the distance from the sphincter to the ciliary margin in the adult, but which was at the fetal period in question the edge of the advancing iris. At the seventh month of intrauterine life all trace of this capsulo-pupillary sheath should in the normal process fade away, while the iris continues to concentrate yet nearer to the axis of the eye.

As I showed in my paper of 1888, it is easy to see how, by the failure in one or other of these successive steps, by which the final condition which we recognize as normal is arrived at, different vestigial anomalies may result. Proceeding from behind forwards we may have:

1. Persistent hyaloid artery or patent canal of Stilling.
2. Some opacities occasionally seen in the hyaloid fossa, due to retention or failure to clarify, of some portion of the posterior part of the capsulo-pupillary tunic.
3. Some instances of circumscribed opaque plaques on the anterior surface of the lens, either with or without connecting threads with the iris; also some cases of capsular cataract and of otherwise inexplicable anterior polar cataract.
4. Many varieties, which I figured, of persistent pupillary membrane.

CHEMICO-PHYSICAL PROPERTIES OF THE LENS.

Chemically the lens is a bag of watery albumin, consisting of globulin, some alkali-albumin, and serum-albumin, and possibly some other albuminoid bodies. Its globulin appears to differ from other globulins, and to resemble vitellin in not being precipitated from dilute brine by saturation. There

are also traces of salts and of cholesterin and lecithin in the normal lens. In a paper read before the British Medical Association at Leeds in 1889 I set out the results of some analyses I had made of the healthy and the cataractous human lens. I found that the clear lens contained about 70 per cent. of water (69 to 73) and 30 per cent. of solids, and of these solids 2 per cent. remained as ash after incineration. I discovered that the percentage of water in healthy lenses was much the same in a child of 10, in an adult, and in a person over 60 years of age. These results differ somewhat from those of other observers. True, the number of fresh clear human lenses at any time available for such analysis is not large, but I may mention that they were all removed from recently-excised eyes, not from *post-mortem* cases, mostly from cases of injury or of growth not affecting the lens, and were generally on the water-bath in my laboratory within an hour of removal from the living body.*

Physically the crystalline is in man a biconvex lens, with an anterior curvature of 10 mm. radius and a posterior of 6 mm. during repose. Its specific gravity is about 1.130 compared to water 1000, and as the ratio of water to solids remains constant in the clear lens throughout life, so does the specific gravity. The bearing of these facts on the alleged increase of density with age usually vouchsafed as the cause of presbyopia I shall discuss later on. The mean refractive index of the lens has been variously given as from 1.38 to 1.45, and some observers have found a slightly greater refractive index in the nuclear than in the cortical layers. It has also the property of double refraction.

The lens substance is, during life, almost perfectly diaphanous, but owing to its sectorial construction the image formed by it is not absolutely stigmatic. That form of astigmatism known as irregular, which gives the "stellate" appearance to the stars, is attributable to the arrangement of the lens fibres. Some spherical aberration is also attributable to the crystalline regarded as a lens, and some entoptic phenomena are referable to the curious disposition of its fibres betwixt tri-radial axes; this disposition may even be seen objectively in some clear lenses under certain modes of illumination, and in disease it is often disclosed very conspicuously.

The lens is truly described as very elastic in the sense of readily tending to resume its original form and volume after the withdrawal of any force that has modified its form or volume. I should not be disposed to allow that the same elasticity is true of its capsule, though this is alleged by most authors. From a study of it in dissection and in operations in health and in disease, I should be more disposed to say with Bowman, it is "a hard and dense structure, and determines the exact outline of the lens." On laceration it gapes and sometimes curls in a fashion suggesting that it is held taut by the reefing-lines that bind it to the ciliary processes. The capsule is composed of albuminoid substance, and not of elastic tissue, and betrays no trace of cellular structure.

Histologically the crystalline presents the most perfect exhibition of continuity alike in time and space betwixt cells and fibres. Thus the flattened epithelial cells beneath the anterior capsule, the lineal descendants of the cells which form the anterior wall of the primitive lens follicle, are seen towards the equator (where growth of the lens by superposition is most marked) to elongate with exquisite gradation into nucleated fibres. These attenuated fibres may be shown to be $\frac{1}{1000}$ in. broad, and hexagonal on section, while in some fishes their edges are markedly dentated.

THE LIFE-HISTORY OF THE LENS.

I now proceed to what I conceive to be the most interesting and the most important considerations, both physiologically and pathologically, in the life-history of the crystalline lens.

From what we have already said as to its origin from isolated epiblast, its growth by equatorial accretion of cell-born fibres, with its oldest elements enwrapped in the deeper nuclear layers, we should, *a priori*, expect the lens to grow continuously from infancy to age. Its epiblastic homologues—for example, epidermis and hair and nails—while in some

respects similarly regenerated, are liable to accidents of surface, such as attrition and adventitious destruction, from which the lens, securely encapsuled yet nurtured by circumambient fluid, is practically immune. Alone of all the tissues of the body it seems to live an enchanted existence endowed with endless growth. It is in this very peculiarity there lie hid the sources of disease and default.

From my own observations and those of others I find that the human lens at birth, which approximates to the spherical form of the crystalline in fish, weighs about 120 mg., at 10 years of age about 160 mg., at 25 about 190 mg., at 45 about 220 mg., at 65 about 250 mg., and at 80 about 260 mg.

Becker found the volume of the lens at 20 to be 155 c.mm. at 50, 195 c.mm.; and at 60, 217 c.mm. Priestley Smith, from a large number of examinations of lenses taken from the body after death, found the volume of the lens increased with great regularity from 163 c.mm. in the third decade to 225 c.mm. in the seventh decade.

The antero-posterior diameter of the lens at birth is 4 mm., it is 5 mm. at 20, and 6 mm. at 60. The transverse diameter, on the other hand, is about 5 mm. at birth, 8 mm. at 20, 9 mm. at 50, and 10 mm. in advanced life.

Remember that the specific gravity remains nearly constant throughout life, and therefore increase of weight means increase of bulk, and this increase of bulk is largely due to equatorial expansion converting a spheroidal lens at birth into an ellipsoid in the adult by progressively filling up the intracapsular circumlental space. I have endeavoured in the accompanying diagram to indicate roughly the change in form which accompanies the growth of the lens. The shaded portion represents post-natal addition.

Rough diagram to illustrate growth of lens from infancy to age.

The prevalent teaching, then, that the healthy lens becomes more solid as age advances, if this is to be held to mean that the older lens contains more solids in proportion and less water than the young, or that the lens becomes denser in the sense that its specific gravity is increased, is a doctrine not founded on fact, and must be discarded as fallacious; and, in so far as such explanation is vouchsafed as accounting for the progressive loss of accommodation which accompanies advancing years, culminating in presbyopia, such pathology must be accordingly discounted.

The progressive increase in bulk of the lens from infancy to age needs to be enforced, and must be correlated with the progressive loss of accommodation which proceeds *pari passu*, and for which, in my opinion, it accounts.*

Becker, whose work on the crystalline is monumental, considered that the growth of the lens was arrested with the growth of the individual, at about 25. Bader, who recorded the fact that a lens at 70 is nearly as heavy again as a lens of 20, attributed this to an assumed increase of density. Norris, in 1889, though referring to Priestley Smith's and my researches, yet states that after adult life the lens grows but slowly.

Donders taught that there was an increase of solidity in the lens with age, and thus explained presbyopia and hypermetropia *acquisita*. Quain's *Anatomy*, in 1904, alleges an increase of specific gravity in age. Lawson speaks of a loss of fluid in advancing years. Schwalbe, in Landolt and Wecker's *Traité Complet*, presuming on some unsatisfactory analyses of Deutschmann, alleges a cornification of, and loss of water by, the lens with advancing years. But, as I pointed out in a lecture on the Pathology of Cataract¹ at St. Bartholomew's Hospital in 1896,

* This correlation between increasing bulk of lens and loss of accommodation power was exhibited in the form of a diagram based upon the following figures:

* Water and solids in lens (W. J. C.):

Age.	Weight in Grams.	Water.	Solids.	Water per Cent.
10 ...	163 ...	113 ...	50 ...	69
27 ...	188 ...	136 ...	52 ...	72
40 ...	217 ...	157 ...	60 ...	72
64 ...	247 ...	176 ...	71 ...	71

In cataracts:

Water 62 per cent.
Solids 38 per cent.

Age.	Weight of Lens in Milligrams.	Amount of Accommodation in Dioptries.
10 ...	160 ...	14.0
25 ...	190 ...	8.5
45 ...	220 ...	4.0
65 ...	250 ...	0.5
80 ...	260 ...	0.0

the fictitious sclerosis of the lens fibres, which has been alleged, in so far as that term suggests dehydration, is in no sense corollary to its derivation from cuticular epiblast or its homologous relationship with the epidermis. Because the latter exposed to air and pressure tends to cornification and dehydration from its surface, that, I submit, is no reason why the lens, excluded from air—nay, bathed with fluid—should exhibit a similar change at its nucleus, which is required to make this fallacious analogy complete. The growth and nutrition of the lens are without parallel in any other tissue of the body.

PRESBYOPIA.

Neither is the other explanation generally called in to explain the progressive loss of accommodation any more equal to the task—I mean the alleged enfeeblement of the ciliary muscle. This muscle, though unstriated yet voluntary, is scarcely likely to be so different from all other voluntary muscles that it should become the victim of a progressive palsy at the very time when the other muscles are increasing in power and development. Moreover, microscopic examination of ciliary muscles at different ages lends no support to this view.

Accepting the statement that the ciliary muscle in contracting constricts the zonule, and thereby acts as a *lavator capsulae lentis*, the extent to which the elastic lens will change its form so as to increase the curvature and refractive power (chiefly of its anterior surface) must be materially affected by its increased bulk and equatorial growth as age advances. The elasticity of the capsule is not great and is certainly not unlimited; even after removal of a lens the remaining capsule is tightly stretched by the cordage of the zonule.

As the lens grows into its capsule equatorially, every year witnesses some encroachment upon the intracapsular circumlental space, and as this potential cavity becomes occupied by the augmented lens in a passive state of refraction less space and opportunity are afforded for that occasional active expansion which effects accommodation. This, I submit, affords an explanation of that remarkable correlation which I have pointed out between the progressive growth of the lens through life, and the progressive loss of accommodative power from youth to age.

I have thus been led by my investigations to propound an entirely new theory of the causation of presbyopia, which I venture to leave to your critical consideration.

Moreover, the gradual repletion of the circumlental space by the equatorial extension of the lens in later life occasions a predisposition to blockade of the filtration angle of the anterior chamber, and thus facilitates the precipitation of an attack of glaucoma. Such a sequence of events is rather more likely to come about in eyes in which the perilental space is small to start with, as is said to be the case in hypermetropia.

SENILE CATARACT.

The prevalent but erroneous teaching of the cornification and solidification of the crystalline lens as a natural senile change is responsible for the equally prevalent doctrine that the changes in the lens which we speak of as senile cataract are, in fact, merely exaggerated and intensified or accelerated senile changes. My investigations lead me to believe they are nothing of the kind, and, indeed, in some respects, the changes exhibited in cataractous lenses are the reverse of the changes which age alone brings. Thus cataractous lenses, unlike old lenses, are usually less in bulk and lighter in weight than clear lenses of corresponding ages are. In my experience it is rare to find a cataract weighing as much as 200 mg., a weight which is usually surpassed by the healthy lens at 40 years of age. If cataract were but premature senility of the lens we should expect to find cataracts weighing heavier, not lighter, than healthy lenses—114 to 136 mg. is the range of weight of a series of cataracts which I have weighed from persons of 46 to 87 years of age.

Again, I have found that while age alone gives no increase in the percentage of solids contained in the lens, in cataract the percentage of solids is increased from 30 to 38 per cent., and there is some increase in the ash.

Besides loss of weight and loss of water observed in cataractous lenses there are certain chemical bodies found in relative excess whose presence and amount favour the view that they have been occasioned by transformation of the albuminoid bodies contained in the normal lens, a transformation presumably due to some failure of nutrition. There is more cholesterin and lecithin, sometimes a little fat, and more salts. Dextrose has been found in some diabetic cases. Microscopically, in senile cataract we find marked fibrillation of the lens, with dissociation of the fibres; also granular or fatty degeneration and vacuolation of the fibres. Calcifica-

tion, and even ossification, of the lens have been described, though the latter lacks confirmation. Fluid degeneration is sometimes encountered, and is often spoken of as Morgagnian cataract.

Traumatic cataract arising from penetrating injury is due to swelling and solution of the lens substance under the influence of the aqueous humour, a process which affords the basis of our procedure in the operative treatment of soft cataracts. The absorption and solution may be complete, or evacuation of the swollen lens debris may be necessitated through a corneal incision. In such cases, and also sometimes after extraction of senile cataracts, there may be a regeneration of cells from any epithelial residue which may be left clinging to the capsule.

Lenticular degenerative changes may appear in the cortex or in the nucleus, or in both, or in the zone between the two, or they may be dotted throughout the lens substance. Then, again, there may be opacities upon, or beneath, or in the substance of the anterior capsule. At either pole and upon the anterior capsule are the favourite seats of what I have termed non-pathological cataracts.

Reverting to the question of non-pathological cataracts, I would refer you to a paper² in which I drew attention to the fact that most English textbooks then accepted the usual explanation of anterior polar or capsular cataracts by way of corneal perforation and its consequences to an extent which would seem almost to exclude an embryological explanation of any opacities in that region. Those who are in the habit of minutely observing the conditions of the media of the eye in large clinics, however, cannot fail to come across, and not very infrequently, opacities in or about the crystalline which do not own a pathological origin. Negative history as regards antecedent inflammation and collateral evidence arising from the normal appearance of surrounding structures compel inquiry for some embryological explanation. Here, as elsewhere, the physiological may pass almost imperceptibly into the pathological, and some default in normal embryological processes may pave the way for morbid terminations.

De Wecker, in 1886, wrote, in reference to this question:

Evidently, then, there is still an etiological point which escapes us, and congenital forms of anterior capsular cataract should not be exclusively attributed to a prolonged contact with a perforated cornea, and still less so since the anterior chamber is, as it were, virtual during intrauterine life.

Soelberg Wells, in 1873, had remarked that anterior capsular cataract may be congenital, but is more frequently found in early childhood in consequence of a perforating ulcer. If it is congenital and there are no traces of iritis or of an ulcer of the cornea, it is probably due to some intrauterine arrest of development.

Ammon of Dresden, in 1858, had also called attention to peculiarities at the posterior pole of a congenital nature. He spoke of

an indentation of the posterior capsule, which at times is octagonal, at others quadrangular. Later this disappears, probably through distension of the lens capsule by the growth of the posterior pole of the lens.

He adds:

I do not quite understand the meaning and cause of this peculiar appearance, but it seems likely that it may have some influence on the development of quadrangular congenital posterior cataract.

I have repeatedly pleaded for a more liberal recognition of embryological and non-pathological explanations of many of the opacities found in or around the lens and its capsule, alike at the anterior and posterior poles, and also on the surface of the anterior capsule, either with or without capsulo-iritic attachments. Such recognition of the true nature of these peculiarities has an important bearing on the prognosis of the course that the lesion is likely to pursue, will serve to prevent unfortunate confusion with the products or the processes of disease, and will obviate errors in treatment based on such erroneous etiology.

BLACK CATARACT.

A certain amount of pigment is noticeable in most hard cataracts, varying from a pale amber to dark brown and even black, but black cataract is a *rara avis in terris, nigroque similis cygno*. Its pathology appears to have been somewhat obscurely treated by most English authors. I find no reference to such variety in Nettleship's *Diseases of the Eye*, a passing allusion merely in Juler's handbook, while Berry observes "often the lens is very darkly coloured, when the cataract is said to be black." If this statement means that black cataracts are often met with, it is at variance with the experience of most oculists. Thus Galezewski says: "Quant à ce qui me concerne, j'en ai rencontré jusqu'à présent 9 cas."

The *Transactions of the Ophthalmological Society* contain reports of two cases—one by Mr. MacHardy in 1882, and one by Mr. Power in 1885. The latter, in commenting on his case, remarked on "the rarity of this variety of cataract in England. This was the first example he himself had met with."

Mackenzie, in his comprehensive treatise (1854) has an apposite observation on the difficulty of diagnosis of such cataracts. He says (p. 751):

I have seen a few cases of lenticular cataract in which the opacity was so very dark that, without close examination, the disease might have passed without detection. On concentrating the light on the pupil the opacity appeared striated; such cases have been called black cataracts. I have not seen the lens after it has been extracted in any of these cases.

Accounts of black cataracts recorded prior to the introduction of the ophthalmoscope must be received with reservation, as there is ground for believing that cases of glaucoma, or "amaurosis," or haemorrhage into the vitreous were sometimes so called. Dupuytren had never seen it, and did not believe in its existence; and Delpech, in his great *Dictionnaire* in 1813, doubted the assertion of the ancients that such a form of cataract existed. Janin of Lyons, in 1772, records the successful extraction of black cataract, the first he had met with in 500 operations. He noted that after extraction the capsule became opaque and olive-tinted. J. Scott removed one in 1843 which he says was as black as pitch. Graefe, the elder, diagnosed black cataract in the case of the Duke of Cumberland after other surgeons had diagnosed amaurosis. J. Z. Lawrence had a case, the first in 2,100 patients. Nunneley met with one case in 1,200 extractions. A few other scattered references occur, mostly in foreign authors, the earliest I have come across being that of Rolink, of Jena, in his *Dissertatio de Cataracta* in 1664.

Four cases have come under my own observation, in two of which I performed extraction. The first was in a swarthy woman with raven black hair. Her vision was reduced to counting fingers, but the pupils looked quite black; though the fundus could not be illuminated, it was only by minute examination with oblique illumination that I could convince myself, by observing fine striae and nacreous lustre, that the defective vision was due to lenticular opacity. I extracted the more mature lens. The operation was uncomplicated, but some weeks afterwards there was a little iritis, though when this cleared up she could read small Jaeger type with a plus 15 D. During the iritis I noticed a very interesting appearance; there were some deposits on the back of the cornea, as in serous iritis; with a strong lens I observed that many of these dots were deeply pigmented.

What is the pathology of black cataract? What is the nature of the pigment? It has been alleged that it is due to "infiltration of haematin into the opaque lens." I do not think that explanation is correct; it certainly will not hold for all cases. I tried soaking extracted cataracts and clear lenses in fresh blood, but found they absorbed haemoglobin with difficulty. Moreover, spectroscopic examination in one of my cases failed to give any evidence of blood pigment. In a case recorded by Hulme, Dr. Harley found that, with HCl and KCNS under the microscope, a red colour was obtained, and that it was to be inferred that iron was present. Hulke examined the lens in Windsor's case, but confessed himself unable to determine the nature of the pigment.

Now I do not think any essential distinction can be drawn between the amber tint of an ordinary cataract when seen by transmitted light and the "black" cataract. Indeed, intermediate examples running through all the shades of a London fog could be found. Now the lens is of cuticular ancestry, and tissues are apt, under certain conditions, which we call pathological, to revert to ancestral habits. The pigment of the negro's skin resides in and is elaborated by the deepest layers of the cuticle. The lens, therefore, contains the progeny of cells whose homologues can produce pigment. *A priori* it would appear not improbable that the pigment is the same in each case. In the outer layer of the optic cup, also derived from epiblast, we have evidence of the pigment-forming capacities of cuticular cells when withdrawn from the surface. Indeed, is not the abundant presence of a form of keratin in the brain a curious chemical testimony to its epiblastic derivation? When these reflections are supported by the fact of the spectroscopic and chemical analyses of the lens pigment differing markedly from those of pigment directly derived from blood, the conclusion may appear to be strengthened that the colour of brown and black cataracts is analogous to that in the rete mucosum, the so-called melanin. Of course, it must not be forgotten that the lens

may, in rare cases, be stained by pigment proximately derived from adjacent blood effusion, or that a melanotic sarcoma of the ciliary body may even invade the lens, not to speak of the common attachment of uveal pigment to the anterior capsule consecutive on iritis. That the pigment in question is not any proximate derivative of haemoglobin, but that it is the product of cell activity, like the pigment of hair or of the skin, is, I think, tolerably clear.

THE MATURATION OF CATARACTS.

"Never prophesy unless you know" is advice especially applicable to any speculation as to the rate at which cataracts will mature. Experience may, however, help approximations to accuracy, especially by the careful observation of collateral signs and symptoms. Thus cataracts associated with myopia are prone to slow ripening. Here is a note of an interesting case in illustration:

When I was clinical assistant to Mr. George Lawson, at Moorfields, I saw a man, aged 85, who, contrary to the habit of out-patients, had preserved and brought with him an old out-patient letter bearing Sir William Bowman's name, and the date July 24th, 1862. The note of that date was: "Left eye, cataract nearly mature, fingers within six inches; right eye, words of No. 2, myopic." On September 21st, 1886, under atropine, I noted that the cataracts were partial; in the left there was a very dense white nucleus and cortical striae, occupying all except the uppermost part; likewise in the right the upper part is alone clear. Through these gaps the fundus of each eye could be seen, and, indeed, large posterior staphylomata. Here, then, was a case in which twenty-four years had witnessed scarcely any ripening.

Cataracts beginning at the posterior pole, or by striae, with anterior concavity stretching thence to the equator, are often slow in maturing. There may be some fallacy in this statement, by reason of our estimation of maturity by the amount of clear cortex, through which the iris shadow is cast on the deeper opacity. But allowing for such mere verbal fallacy, I believe that the opacification spreads less quickly through a lens under such circumstances than when the first departure from pellucidity is nuclear or is anteriorly placed. As an illustration of what I mean, and of the rapid influence of iridectomy in accelerating maturation, I may cite the case of a gentleman who was the secretary of a well-known microscopical society:

He was 51 in 1886, when he consulted me about his eyes; his sight had then been falling for twelve years. His vision was reduced in the left eye to 30, and with the right eye he could count fingers at 3 ft.; he was unable to use his microscope, which was to him a great deprivation. His lenses exhibited posterior opacities at the pole, and concave striae proceeding arcwise therefrom; there was apparently some axial myopia. The cataracts were in a condition then accounted too unripe for extraction, but ripe enough to excommunicate their unfortunate possessor from most of the pleasures of his life. On October 8th, 1886, I did a preliminary iridectomy on the right eye, and on January 7th, 1887, the cataract to all appearances being perfectly ripe, I extracted it, with a resulting vision of J. 1. and 5, with glasses. I had occasion to see the patient again some eight years afterwards, and found the other eye practically *in statu quo*, red reflex could still be obtained, and the anterior hemisphere of the lens was for the most part pellucid. He had resumed his favourite investigations of diatoms with the microscope with the operated eye, and was so well satisfied with it that he would not yield to my suggestion to deal similarly with the other.

This case enforces the slow maturation of cataracts of this class, and their rapid ripening by iridectomy, and indicates the mode of escape from the intolerable dilemma, wherein the lenses are opaque enough to frustrate useful vision, and clear enough to preclude extraction with a clear conscience. An iridectomy performed with this object should be a large one, and the iris should be removed well up to its ciliary border. I have seen disappointing results attend iridectomies done with a view to maturation where these points have not been attended to.

Methods of trituration of immature cataracts with the object of ripening them are not, in my opinion, very advisable. Such methods should certainly be confined to extra-ocular manipulations. I am led to doubt the value of such procedure the more because I have found that the dangers apprehended in the attempted extraction of lenses not largely opaque have been unduly magnified. This opinion is by no means a new one, for I find that Samuel Johnson, writing on October 18th, 1760, to a Mr. Langton, said:

Mr. Sharpe is of opinion that the tedious maturation of the cataract is a vulgar error, and that it may be removed as soon as it is formed. This notion deserves to be considered. I doubt whether it be universally true, but if it be true in some cases, and those cases can be distinguished, it may save a long and uncomfortable delay.

It is interesting to note both the prescience and the caution which mark the pathological opinions of the great lexicographer.

THE CLASSIFICATION OF CATARACTS.

The ordinary classifications of cataract are hopelessly illogical, it is to be hoped that the practical man, who scorns logic, finds them proportionately "practical." They lack a common *basis divisionis*. Age, consistence, situation, cause, etc., are evoked as bases in the same classification, with a bewildering effect. No mere dichotomous division as into hard and soft, senile and juvenile, is satisfactory. Still less is there any special value in distinguishing between nuclear and cortical cataract, and the existence of laminar cataract makes such division non-exhaustive.

Etiology is doubtless the best basis for classification, but while the pathology remains in part obscure, no complete and satisfactory classification is possible. As an approximation to such an arrangement I would submit the following:

CATARACT.

Opacity of lens or capsule attributable to:

1. Developmental causes: (1) Congenital, remains of capsulo-pupillary envelope, dot cataracts, etc.; (2) Infantile—for example, laminar.

2. Cachectic causes: for example, toxæmia: (1) From without—for example, ergot, naphthalin, etc.; (2) from within—for example, diabetes.

3. Secondary results of ocular disease—for example, some anterior polar cataracts; myopic cataracts; glaucomatous cataracts.

4. Vascular disease—for example, atheroma of carotids, aneurysm.

5. Nervous disease—for example, disease of fifth nerve or of the Gasserian ganglion.

6. Traumatism, direct, or indirect—for example, result of dislocation.

In reference to the toxæmic group, I would associate myself with those who think the influence of diabetes as a cause of cataract has been over-estimated. Von Graefe put 25 per cent. down to this cause. Probably less than 1 per cent. is nearer the truth, and the co-existence of the two conditions does not prove their causal relationship. Atheroma of the arteries is, I believe, a true cause; I remember de Wecker demonstrating the fact in his clinic when I was there some fifteen years ago. Ergotism as an alleged cause is interesting in view of its recognized vaso-constrictive action.

I must now bring these observations to a conclusion. I rejoice to have been permitted to take part in this reunion of earnest students of ophthalmology at the invitation of my old friend and colleague, Mr. Doyne, within the venerable precincts of the University of Oxford. This course of ophthalmology appears to me to have been conceived upon the best didactic methods. We are dealing with a speciality, it is true, but the base of that speciality we are endeavouring to lay on broad, rational and strictly scientific foundations. Dr. Billings, of New York, once wittily said:

A specialist should be a good general practitioner and something more, but he is very often something else.

In the ophthalmic speciality there is happily no place for the empiric and the charlatan. Thanks to the completeness with which we are enabled to make our observations on and within the globe of the eye this microcosm has been made to reveal nearly all its secrets. The great discovery of Helmholtz cannot be again repeated; the joy of being the first to behold the living human retina was his alone. He was, indeed, "the first that ever burst into that silent sea." Yet the same principles of research which animated him may inspire us. What were those principles? He tells us in his autobiography:

I ascribed my success in great measure to the circumstance that, possessing some geometrical capacity, and equipped with a knowledge of physics, I had by good fortune been thrown among medical men, where I found in physiology a virgin soil of great fertility, while on the other hand I was led by the consideration of the vital processes to questions and points of view which are usually foreign to pure mathematicians and physicists.

There is the secret if secret it be. It argues for the unity of knowledge, for the cross-fertilization of the sciences, for keeping the base of all our specialities broad, for the application of the methods of one department of knowledge to the investigation of others, and it behoves us to see to it that all our studies are governed and directed by a whole-hearted devotion to philosophic truth.

REFERENCE.

¹ Medical Press and Circular, July 8th, 1896. ² Lancet, July 16th, 1894.

REQUESTS TO MEDICAL CHARITIES.—The late Mrs. Emma Poncia, of Edgbaston, whose will has now been proved, bequeathed £10,000 each to the Birmingham General Hospital and the Queen's Hospital in the same city.

A Report

ON

HUMAN AND BOVINE TUBERCULOSIS.

Read in German at the Paris Congress on Tuberculosis, 1905.

By PROFESSOR Dr. H. KOSSEL,
Giessen.

EVER since Villemin by his classical researches definitely proved that tuberculosis is an infectious disease, the relations between human and animal tuberculosis have been the object of investigation. Though general opinion favoured a belief in a close connexion between the two, doubts were occasionally raised. The solution of the problem by experiment was often tried, but no definite success was obtained. The difficulty of protecting the experimental animals from unintended infection by tuberculosis frustrated the majority of the attempts. Only when the discovery of the tubercle bacillus by Koch had shown what the infectious agent in tuberculosis was and where it was to be found, did thorough comparative studies become possible.

For the moment, however, the question seemed to be answered in the sense of a uniform germ common to the tuberculosis, at any rate, of the mammals. The micro-organisms cultivated from human tuberculosis resembled so closely those cultivated from "*Perlsucht*" in bovine animals, that no doubt of their identity seemed at that time possible.

It was not before 1896 and 1898 that Theobald Smith raised serious objections to the identity, based on comparative studies of tubercle bacilli from human, bovine, and porcine sources. He called attention to morphological differences apparent in cultures on artificial media as well as to differences in virulence for small animals. Later on Koch—by experiments carried out in common with Schütz on cattle, swine, and sheep—convinced himself that the bacilli of human tuberculosis differed from those of pearl disease. The practical conclusions which he drew changed the question into one of universal interest, for now it had become doubtful whether meat and milk derived from tuberculous animals—which, so far, had been universally considered as an important source of tuberculosis—were really dangerous to human beings. Medical and veterinary experts in all countries devoted themselves to the study of this question. Up to the present day such numbers of papers have been published on it that it seems impossible to deal with them thoroughly in a communication like the present, and this is my reason for refraining from giving a minute review of the literature, and for confining myself chiefly to detailing results which I have obtained during several years at the Kaiserliche Gesundheitsamt at Berlin in collaboration with Weber and Heuss.

Koch's Views.

Koch's new teaching may be thus summed up:—The tuberculosis of man and the pearl disease of cattle owe their wide distribution not to the same germ. By injection of cultures of tubercle bacilli under the skin of cattle it is possible to determine whether one has to deal with a germ from a human or from a bovine source. The tubercle bacillus derived from man cannot produce tuberculosis in cattle. Whether the bovine bacillus produces tuberculosis in a human being has not yet been definitely proved, but even if infection of humans by the bovine germ is possible, it is certainly of rare occurrence. To take measures against this remote possibility is therefore not advisable—or, to use Koch's own words in the German original, "*nicht für geboten*." Koch's words apparently leave nothing to be desired in lucidity of expression, but nevertheless there are some who have not seen that there are really two questions involved:

1. Is *Perlsucht* in cattle spread by the same germ as tuberculosis in man?

2. Is man susceptible to the germ which causes pearl disease in cattle?

Let us begin with the former question:

1. Is *Perlsucht* in Cattle spread by the same Germ as Tuberculosis in Man?

If one follows Koch in cultivating the tubercle bacilli from tuberculous organs of cattle, cultures are obtained showing specific properties. The bacilli are mostly short, rather plump, and give the characteristic staining reactions of tubercle bacilli. They may be cultivated on artificial media, especially on beef serum with or without addition of glycerine