The Wonderful Form of Cosmic Order

Bringing Statistics to Evolution

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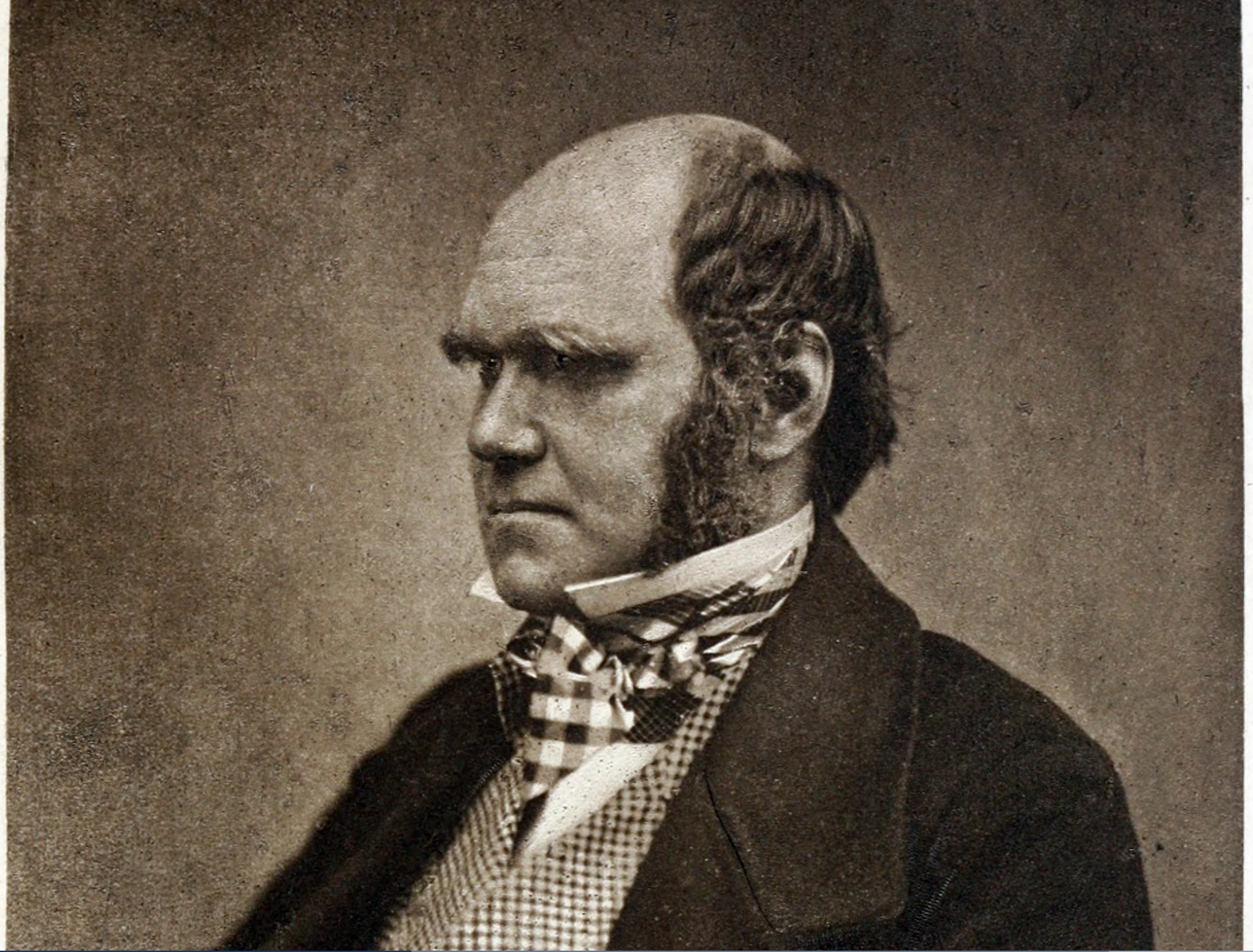
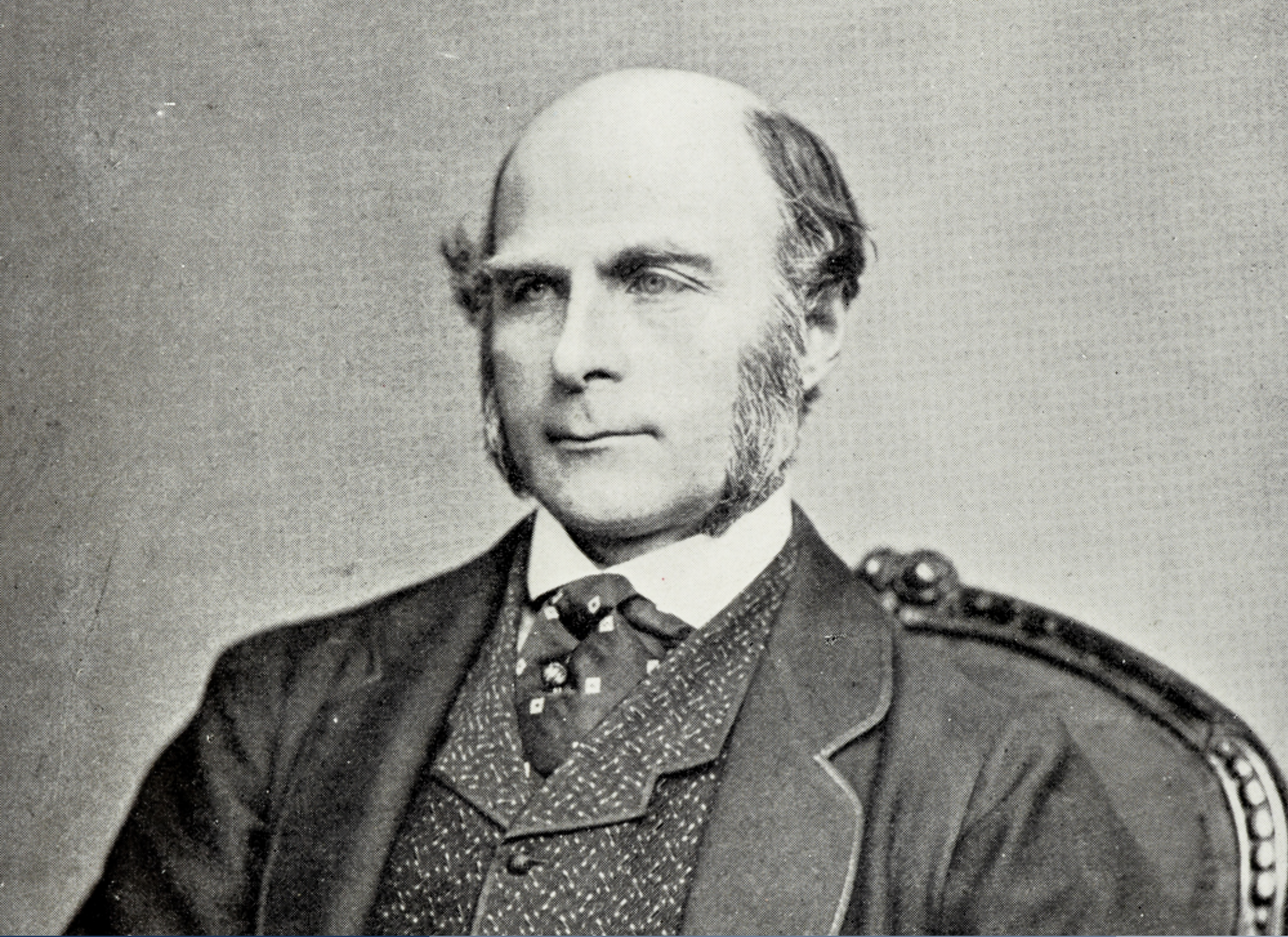
Outline

1. A historical paradox
2. Galton's early work
3. *Natural Inheritance*
   - 3.1 Particulate inheritance
   - 3.2 Chances and causes
   - 3.3 Natural selection (or supposed to be)
4. A research program for biometry
5. Two perennial questions in evolution

The take-home: Galton builds a school around him in no small part because he identifies two central, recurring philosophical issues regarding statistical theories.

A Historical Paradox



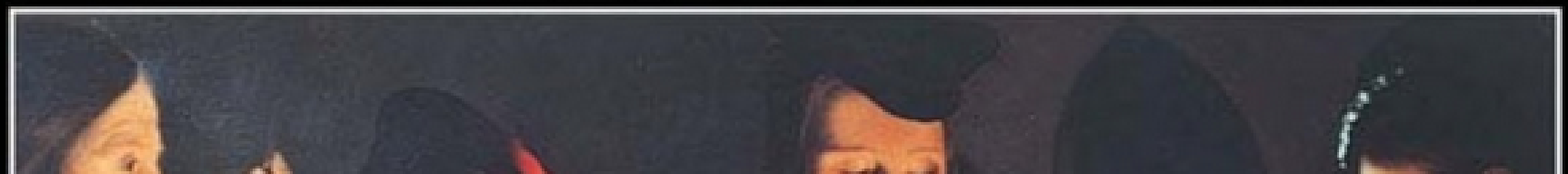


The next year was to place in Weldon's hands a book – Francis Galton's *Natural Inheritance*, by which one avenue to the solution of such problems [in variation, correlation, and evolution], one quantitative method of attacking organic correlation, was opened out to Weldon; and **from this book as source spring two of the friendships and the whole of the biometric movement, which so changed the course of his life and work.** (Pearson 1906, 13–14)

no one who studied it on its appearance and had a receptive and sufficiently trained mathematical mind could deny its great suggestiveness, or be other than grateful for all the new ideas and possible problems which it provided. The methods of *Natural Inheritance* may be antiquated now, but in the history of science **it will be ever memorable as marking a new epoch**… (Pearson 1930, 57–58)

IDEAS IN CONTEXT

THE Taming OF Chance

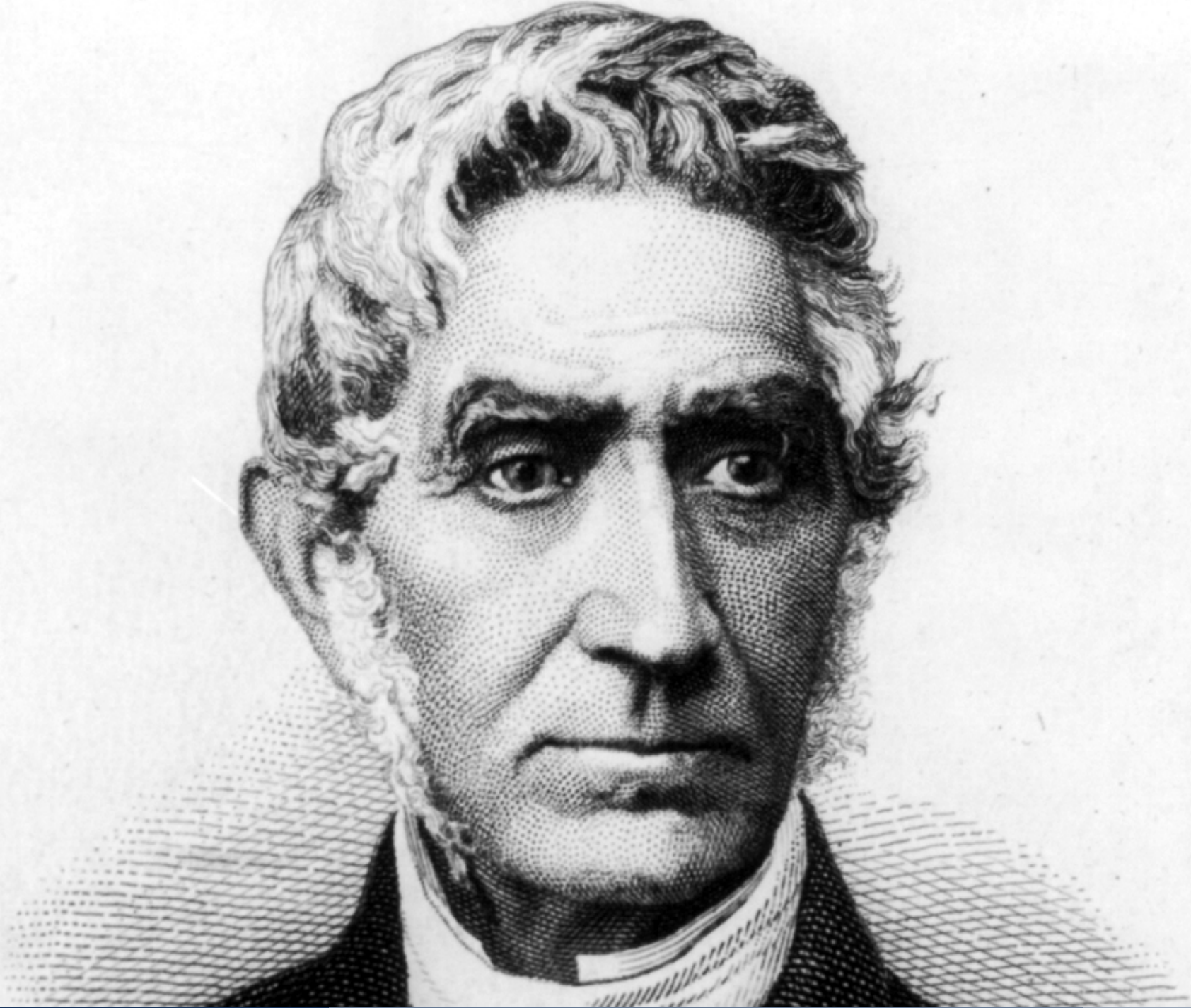


> the argumentation concerning this concept [the idea of "natural ability"] was, as frequently with Galton, very bad, but the concept was powerful if vague.... (Norton 1978, 43)

[The biologist and textbook author W. K. Brooks] included a whole chapter on Galton in his *Foundations of Zoology* and explicitly addressed the ambiguities in his writings by quoting passages that seem both to support and to deny a role for selection in determining the fate of the new characters produced by saltation.

In the end, however, it seems that Galton was simply ambiguous on the question of the role played by selection… (Bowler 2014, 276, 274)

Galton's Early Work



L'homme que je considère ici est, dans la société, l'analogue du centre de gravité dans les corps ; il est la moyenne autour de laquelle oscillent les élémens sociaux : ce sera, si l'on veut, un être fictif pour qui toutes les choses se passeront conformément aux résultats moyens obtenus pour la société. Si l'on cherche à établir, en quelque sorte, les bases d'une *physique sociale*, c'est lui qu'on doit considérer, sans s'arrêter aux cas particuliers ni aux anomalies, et sans rechercher si tel individu peut prendre un développement plus ou moins grand dans l'une de ses facultés.

(Quetelet 1835, 1:21)

Triste condition de l'espèce humaine ! Nous pouvons énumérer d'avance combien d'individus souilleront leur mains du sang de leurs semblables, combien seront faussaires, combien empoisonneurs, à peu près comme on peut énumérer d'avance les naissances et les décès qui doivent avoir lieu. (Quetelet 1835, 1:10)

I know of scarcely anything so apt to impress the imagination as **the wonderful form of cosmic order** expressed by the "law of error." A savage, if he could understand it, would worship it as a god. It reigns with serenity in complete self-effacement amidst the wildest confusion. The huger the mob and the greater the anarchy the more perfect its sway. (Galton 1886, 494–5)

The outline of my problem of this evening is, that since the characteristics of all plants and animals tend to conform to the law of deviation, let us suppose **a typical case, in which the conformity shall be exact,** and which shall admit of discussion as a mathematical problem, and find what the laws of heredity must then be to enable *successive* generations to maintain **statistical identity.** (Galton 1877a, 493)

FIG. 7.

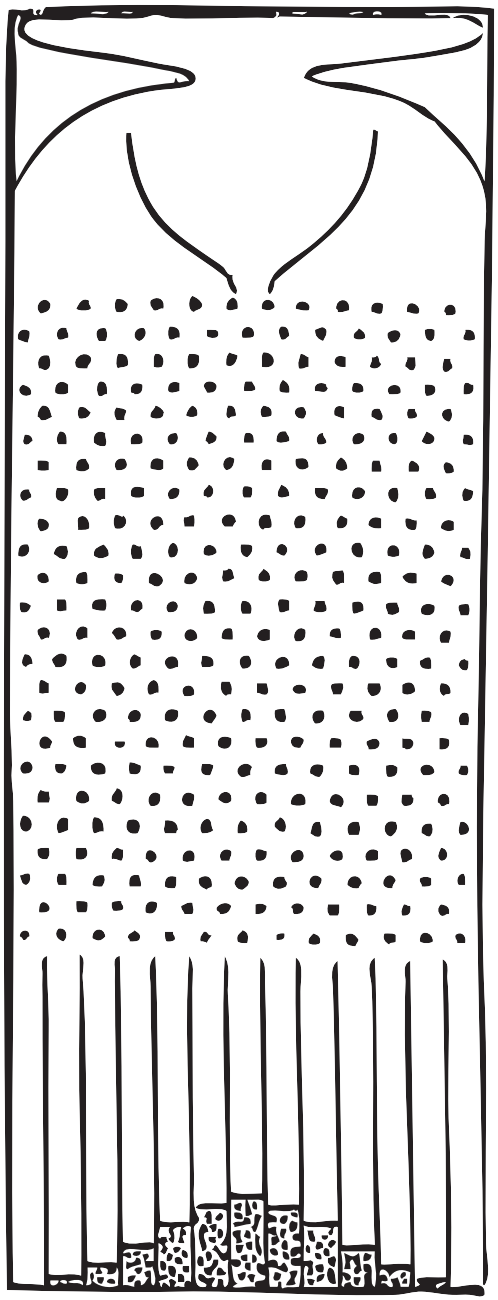


FIG. 8.

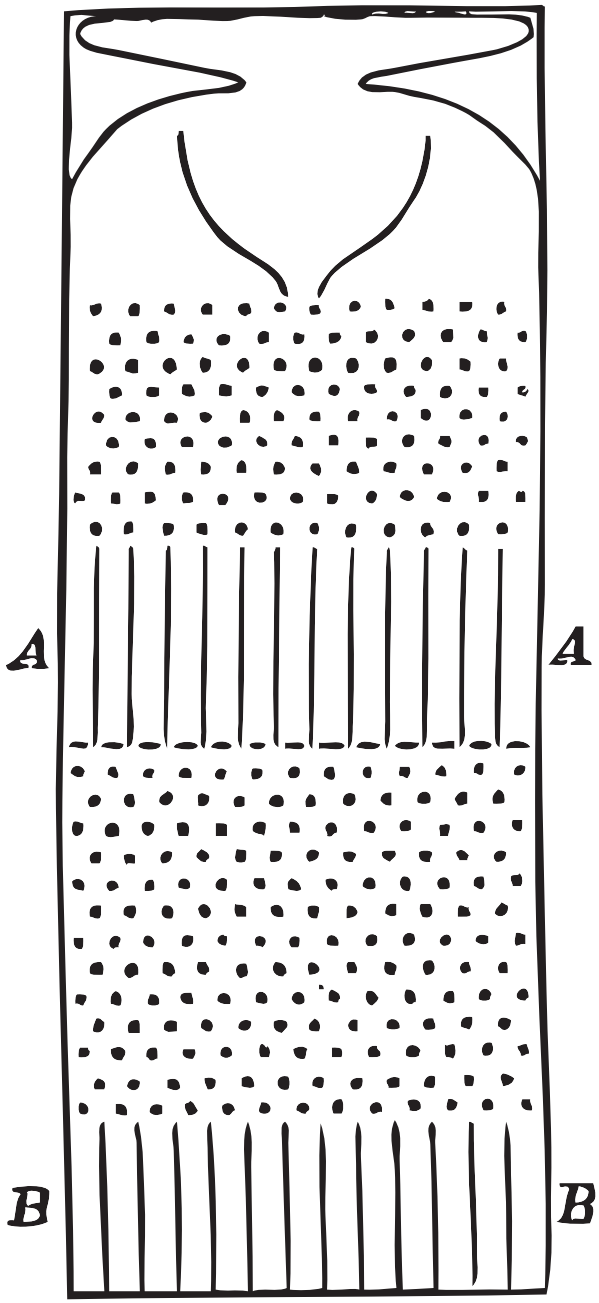
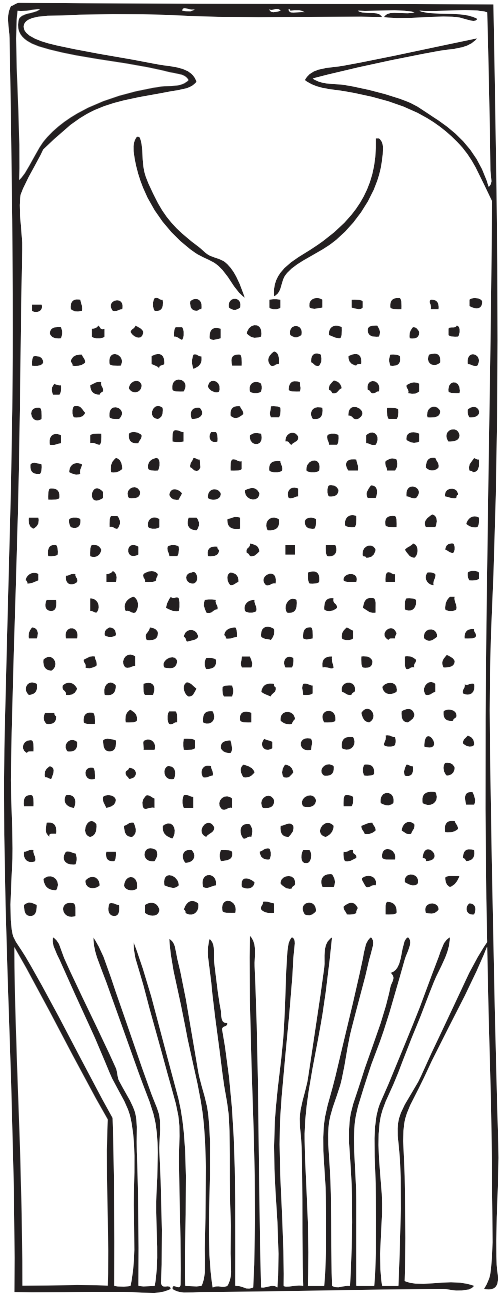


FIG. 9.



[I]n addition to [the constant effects of the mean and gravity] there were **a host of petty disturbing influences,** represented by the spikes among which the pellets tumbled in all sorts of ways. The theory of combination shows that the commonest case is that where a pellet falls equally often to the right of a spike as to the left of it.… It also shows that the cases are very rare of runs of luck carrying the pellet much oftener to one side than the other. (Galton 1877a, 495)

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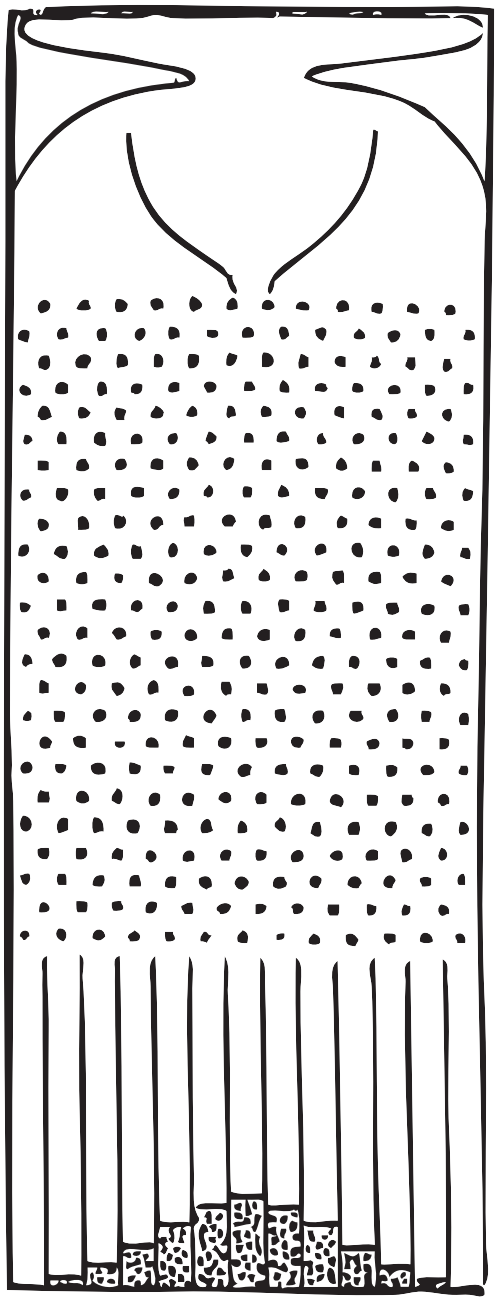

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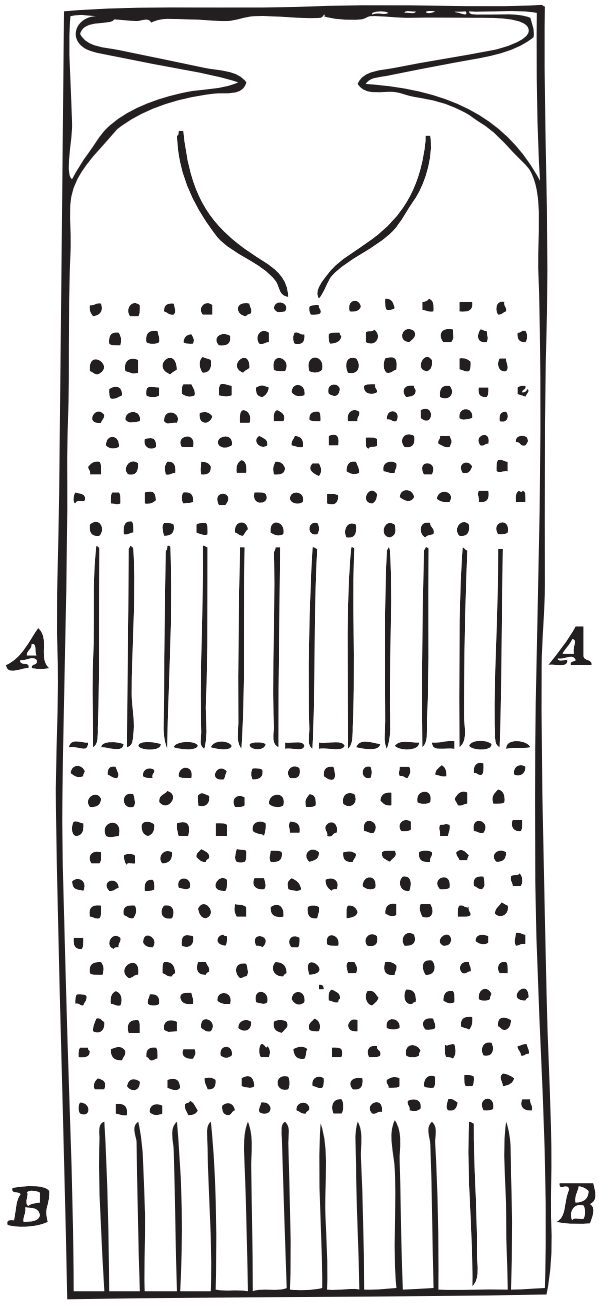

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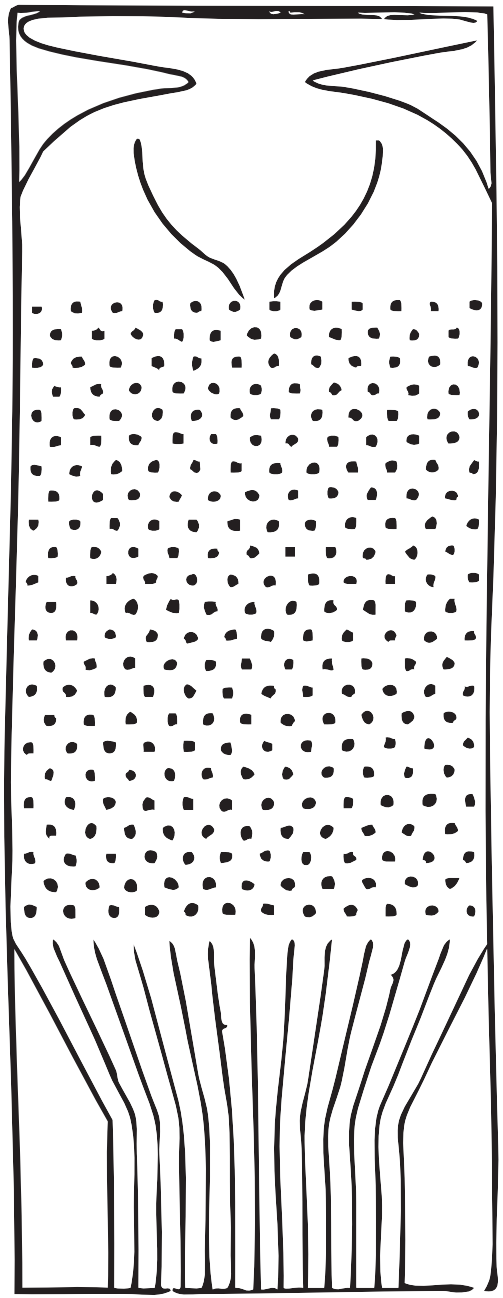


[A]lthough characteristics of plants and animals conform to the law, **the reason of their doing so is as yet totally unexplained.** The essence of the law is that differences should be wholly due to the collective actions of a host of independent *petty* influences in various combinations.... **Now the processes of heredity...are not petty influences, but very important ones.** (Galton 1877b, 512)

Natural Inheritance

It would seem that while the embryo is developing itself, the particles more or less qualified for each new post **wait as it were in competition,** to obtain it. Also that the particle that succeeds, must owe its success **partly to accident of position and partly to being better qualified** than any equally well placed competitor to gain a lodgement. (Galton 1889, 9)

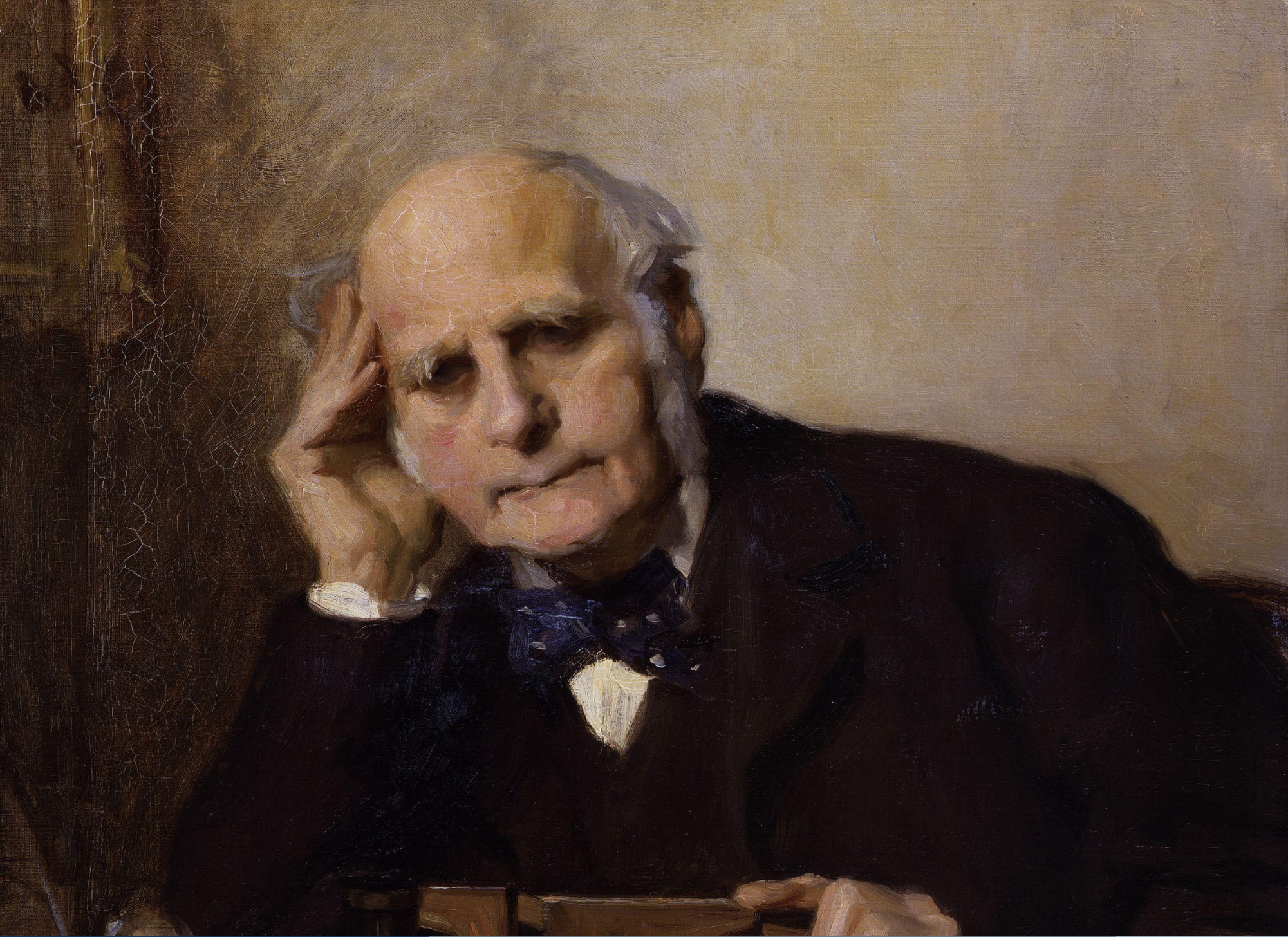
The child inherits partly from his parents, partly from his ancestry. Speaking generally, the further his genealogy goes back, the more numerous and varied will his ancestry become, until they cease to differ from any equally numerous sample taken at haphazard from the race at large. Their mean stature will then be the same as that of the race; in other words, it will be mediocre. Or, to put the same fact into another form, the most probable value of the mid-ancestral deviates in any remote generation is zero. (Galton 1885, 1209)

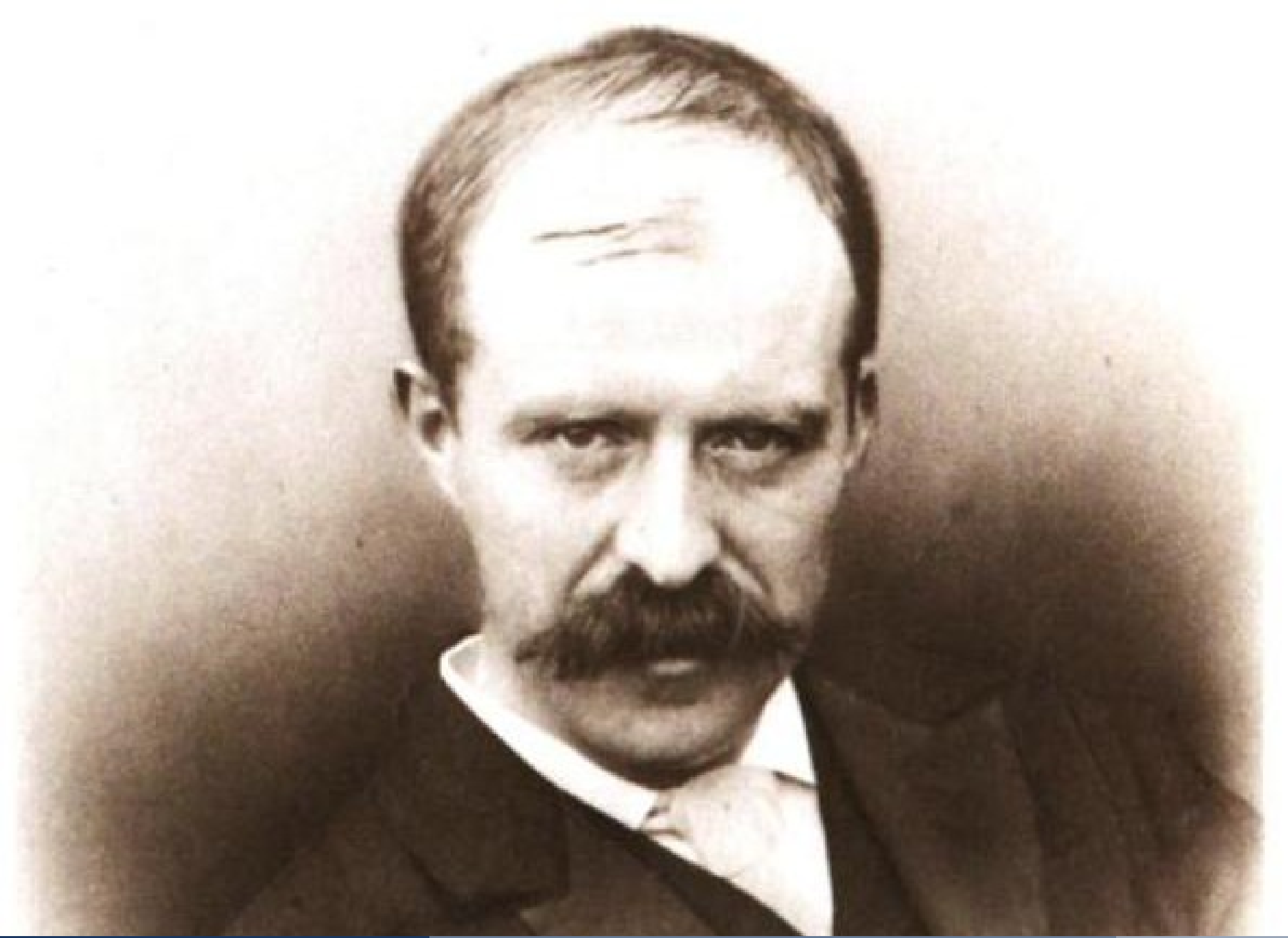
[The first chapter's] intention has been to show the large part that is always played by chance in the course of hereditary transmission, and to establish the importance of an intelligent use of the laws of chance and of the statistical methods that are based upon them, in **expressing the conditions under which heredity acts.** (Galton 1889, 17)

A parade of great accuracy is foolish, **because precision is unattainable in biological and social statistics;** their results being never strictly constant. [...] We require no more than a fairly just and comprehensive method of expressing the way in which each measurable quality is distributed among the members of any group.... (Galton 1889, 36)

Evolution may produce an altogether new type of vessel that shall be more efficient than the old one, but when a particular type of vessel has become adapted to its functions through long experience **it is not possible to produce a mere variety of its type that shall have increased efficiency in some one particular without the rest.** So it is with animals. (Galton 1889, 124)

A New Research Program





heredity and deep ancestry

heredity and deep ancestry

evolutionary dynamics

Two Perennial Questions

What is the relationship between the statistical trends described by biological theory and the processes in the world those trends are intended to describe?

How can we express evolutionary dynamics in statistical terms?

Questions?

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