Quarks, Chaos, and Christianity

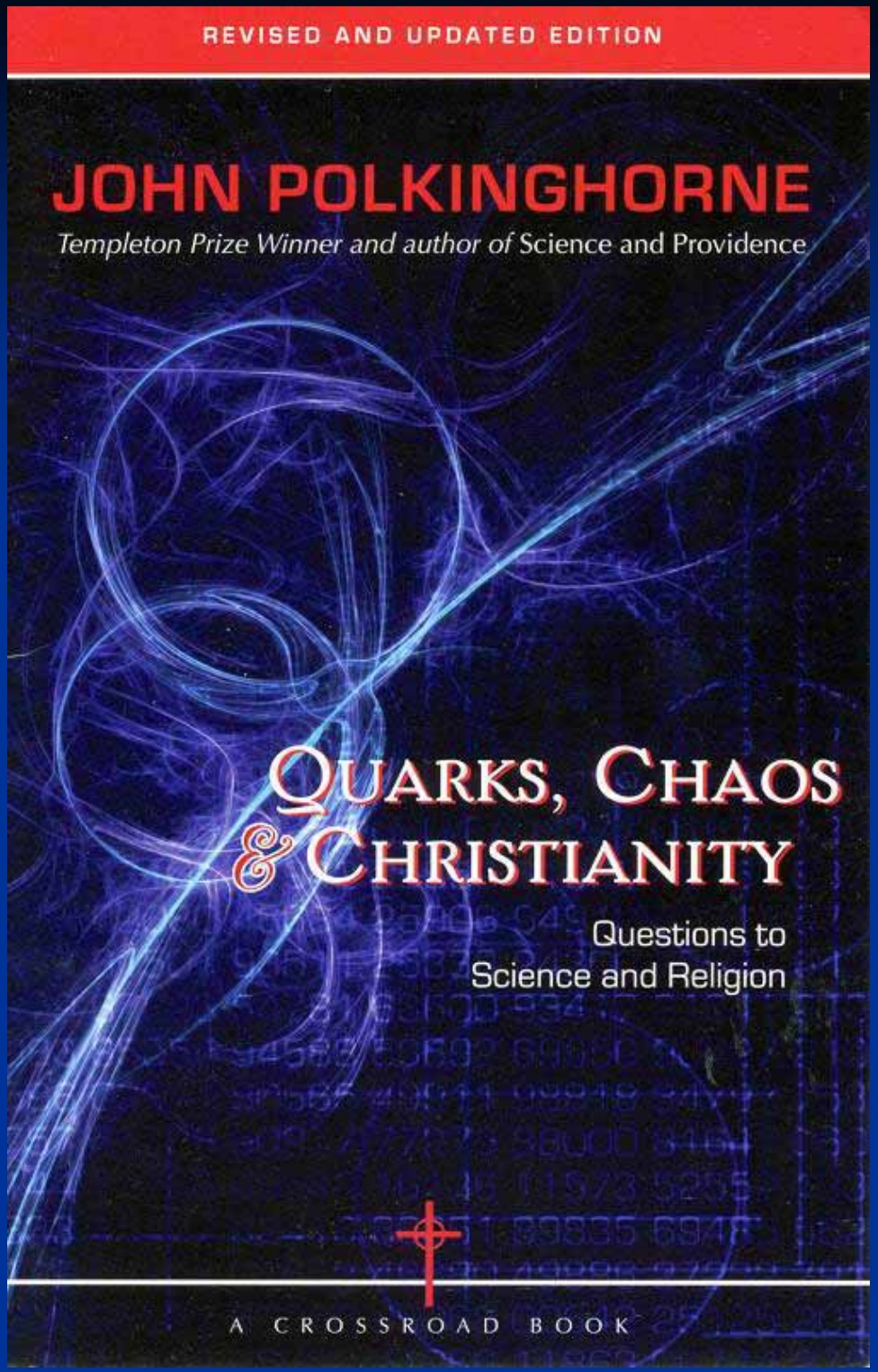
Who Are We?

Sunday, January 27, 2008
10 to 10:50 am, in the Parlor
Presenter: **David Monyak**

St. John in the Wilderness

O God, you made us in your own image and redeemed us through Jesus your Son: Look with compassion on the whole human family; take away the arrogance and hatred which infect our hearts; break down the walls that separate us; unite us in bonds of love; and work through our struggle and confusion to accomplish your purposes on earth; that, in your good time, all nations and races may serve you in harmony around your heavenly throne; through Jesus Christ our Lord.

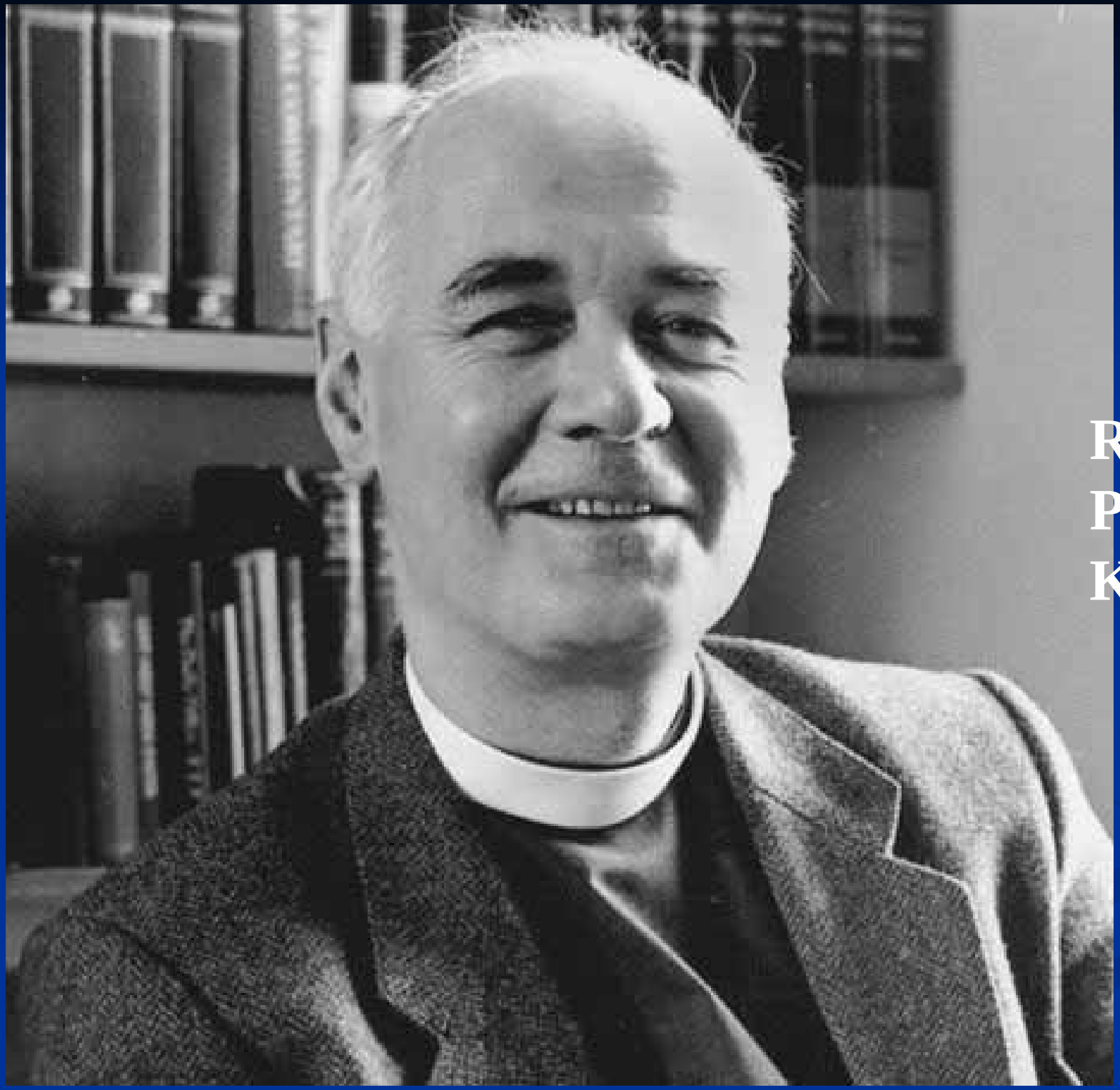
- Book of Common Prayer, p. 815



Primary Reference

- **Quarks, Chaos, & Christianity. Questions to Science and Religion, Revised Edition**, John Polkinghorne, Crossroad, 2005

- **The Rev. Dr. John Polkinghorne KBE, FRS:**
  - **1955:** PhD physics from Cambridge University
  - **1968:** full Professor of Mathematical Physics at Cambridge University
  - published numerous papers on theoretical elementary particle physics
  - **1974:** Fellow of the Royal Society
  - **1979:** resigned his professorship in order to train for the Anglican priesthood
  - **1981 to 1986:** served as a deacon, curate and vicar
  - began writing numerous papers and books on interface between science and religion
  - **1986:** Dean & Chaplain of Trinity College, Cambridge
  - **1989-1996:** President of Queens College, Cambridge
  - **1994-2005:** Canon Theologian of Liverpool Cathedral



Rev. Dr John Polkinghorne KBE FRS

Introduction

Science and Faith

Introduction
The Book of Nature

- In our first session, we asked what did religion and science have to do with each other?
  - Psalm 19:2: **The heavens speak of the Creator's glory and the sky proclaims God's handiwork**
  - St. Paul (Romans 1:20 NRSV): **Ever since the creation of the world his eternal power and divine nature, invisible though they are, have been understood and seen through the things he has made.**
- The "Book of Nature" as well as the "Book of Scripture" can tell us about God.

Introduction
Is Anyone There?

- In our first session we also discussed two questions about “the whole show” that arise out of science, but which science itself cannot answer.
  - **1. Why can we do science at all?** Why are we capable of comprehending and appreciating the rationale beauty of the laws that govern the universe, when such knowledge goes far beyond what we need to survive?
  - **2. Why do we live in a universe whose laws are incredibly fine-tuned to produce life?** (the Anthropic Principle)

Introduction
Is Anyone There?

- *Question 1:* Why can we do science at all?
  - The rational beauty and transparency of the universe (the "reason without") can be comprehended by us (the "reason within") because they have a common origin in the reason of the Creator, who is the ground of all that is.
    - That is: humanity is made "in the image of God," and this is why we can comprehend and appreciate the rationale beauty of God's creation; this is why we can "do science."

Introduction
Is Anyone There?

- *Question 2:* Why do we live in a universe fine-tuned for life?
  - There are two rational answers, *both* of which are "metaphysical" (*beyond* physics):
    - 1. There is a vast number of other universes, each with its own natural laws and circumstances. They are nearly all sterile and lifeless, but we happen to be in one that by sheer chance had the laws and circumstances to produce life.
    - 2. There is only one universe. It is fine tuned for life because it is the creation of a Creator who desires it to be fruitful of life.

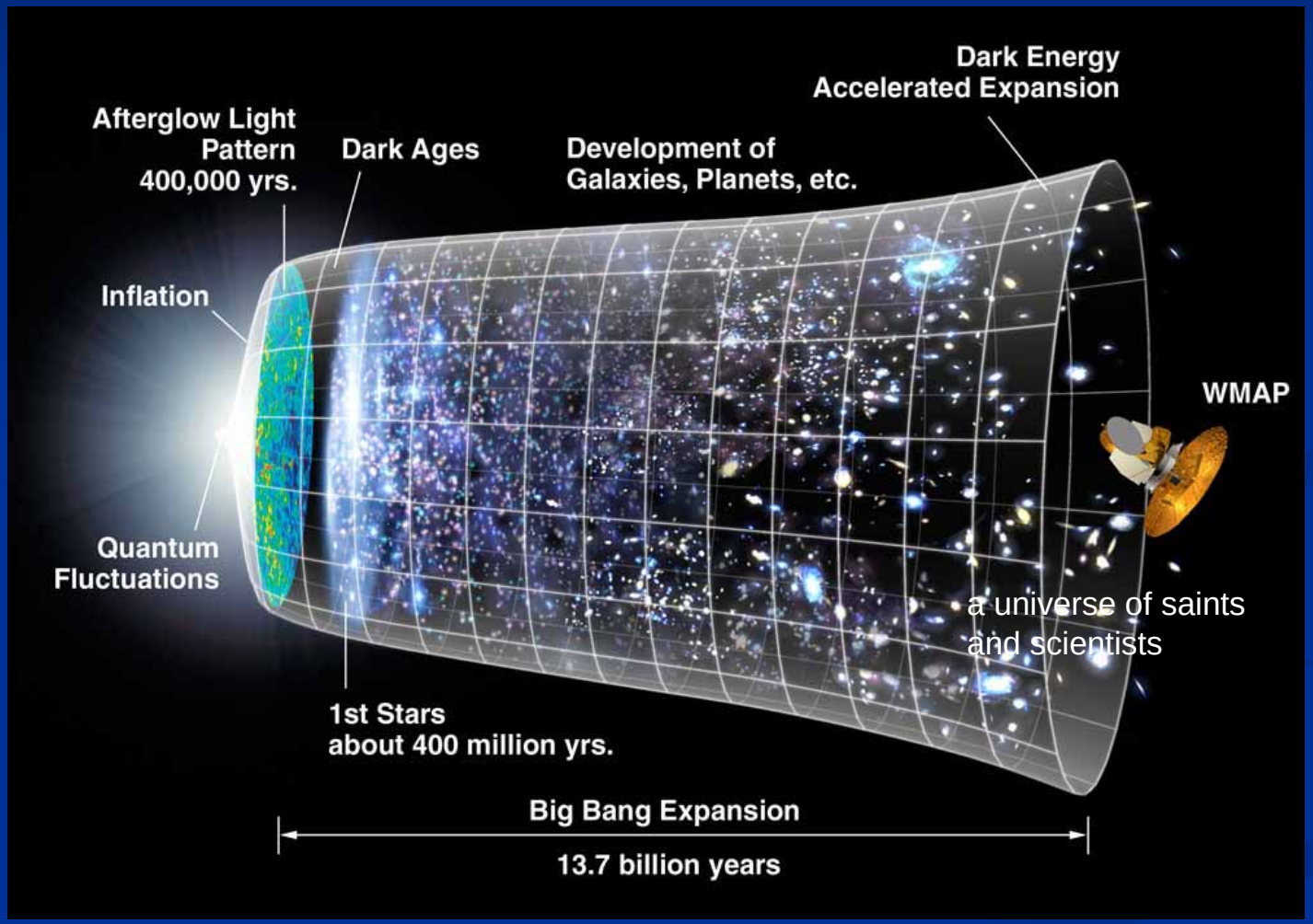
Introduction

What's Been Going On?

- In our second session, we asked the question, "What's been going on?"

Introduction

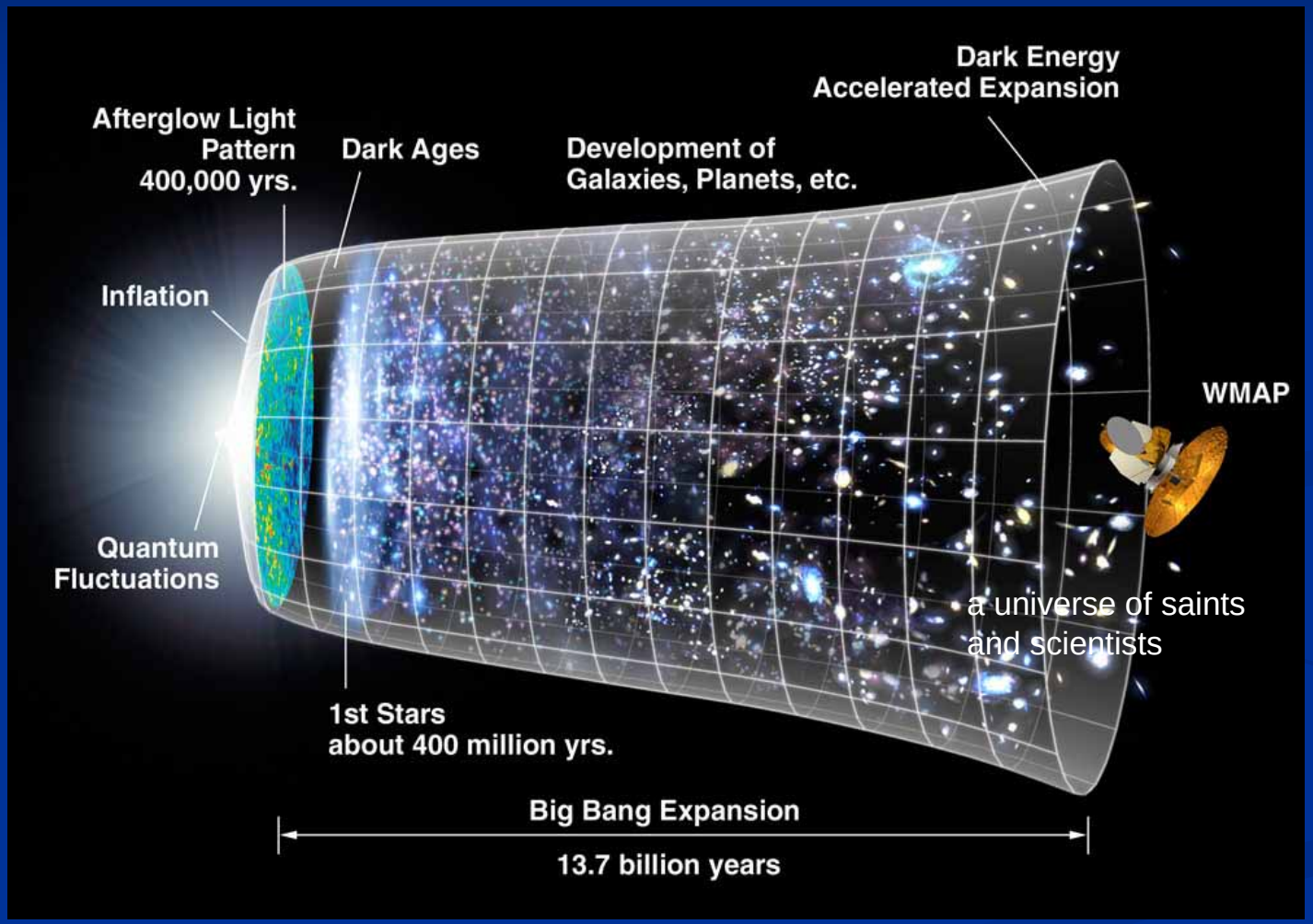
What's Been Going On?



13.7 billion years ago God *began* to create the universe of space-time. God's ***on-going sustaining*** of the universe is best viewed as an ***on-going creation*** of the universe

Introduction

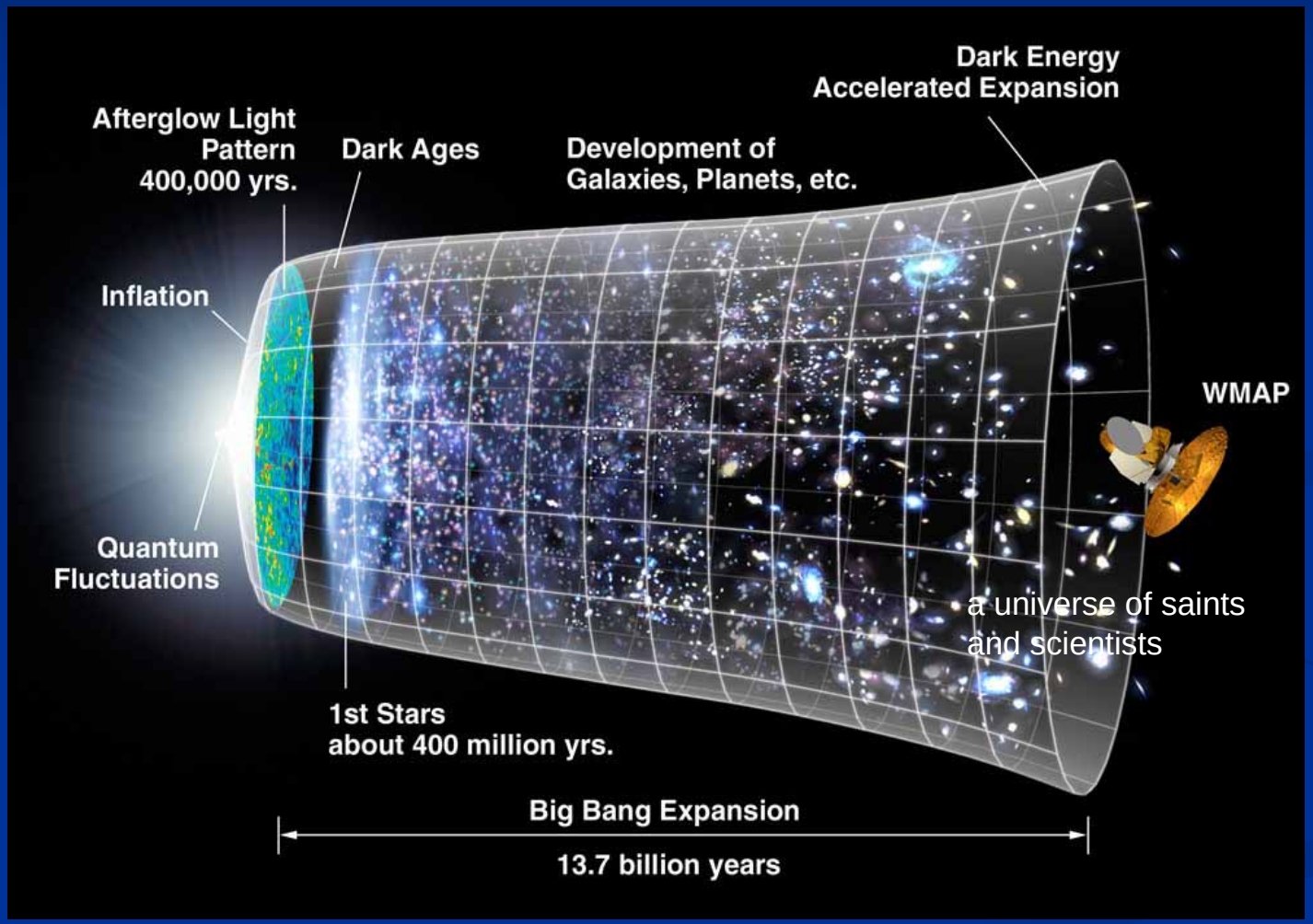
What's Been Going On?



It is a developing, evolving universe, given by faithful and loving God the twin gifts of **reliability** and **independence** so it could be other than God, so it could make itself, be fruitful.

Introduction

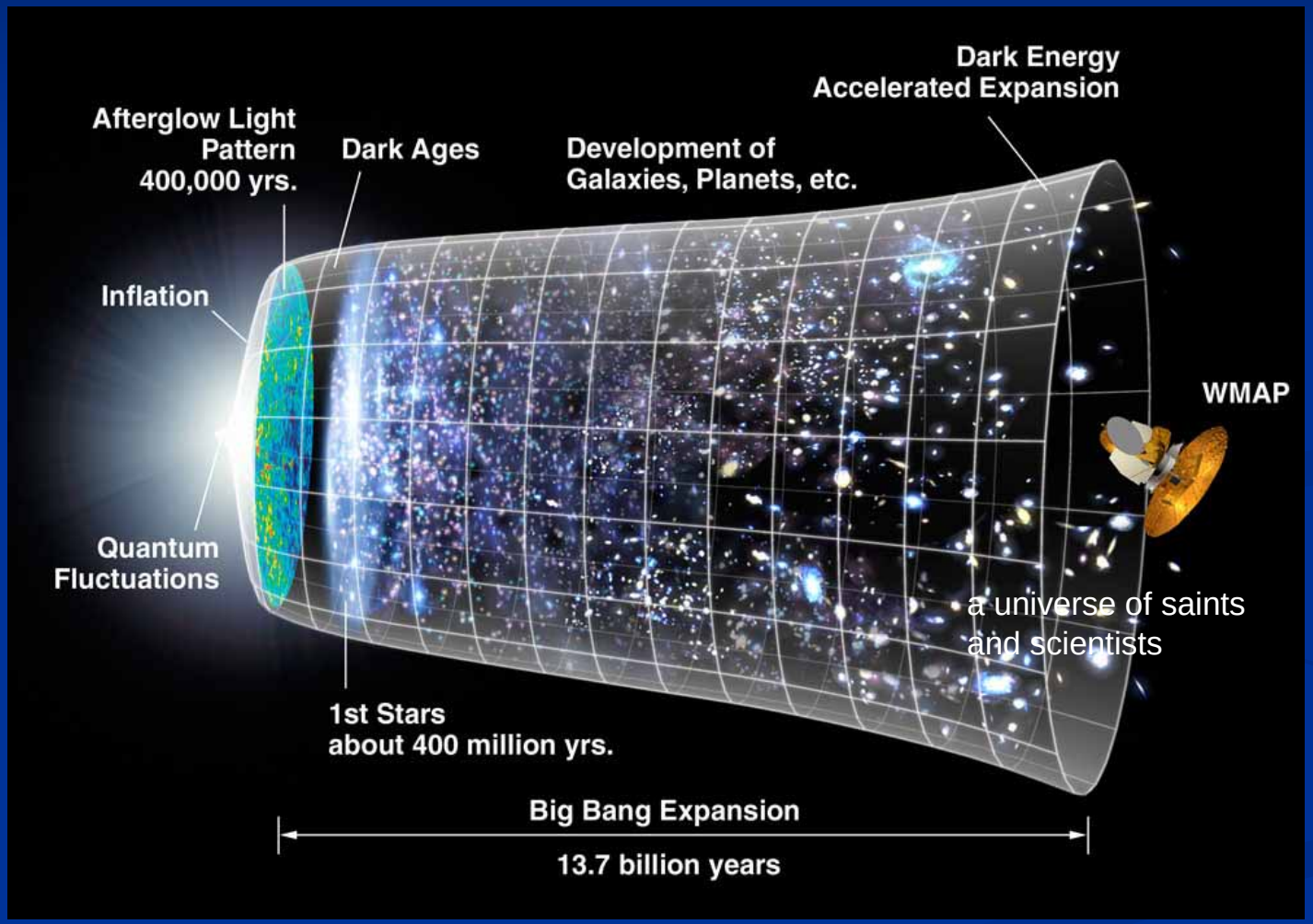
What's Been Going On?



In 13.7 billions years, it has evolved from an unimaginably hot plasma of quarks and gluons to a world of galaxies, stars, planets, saints and scientists.

Introduction

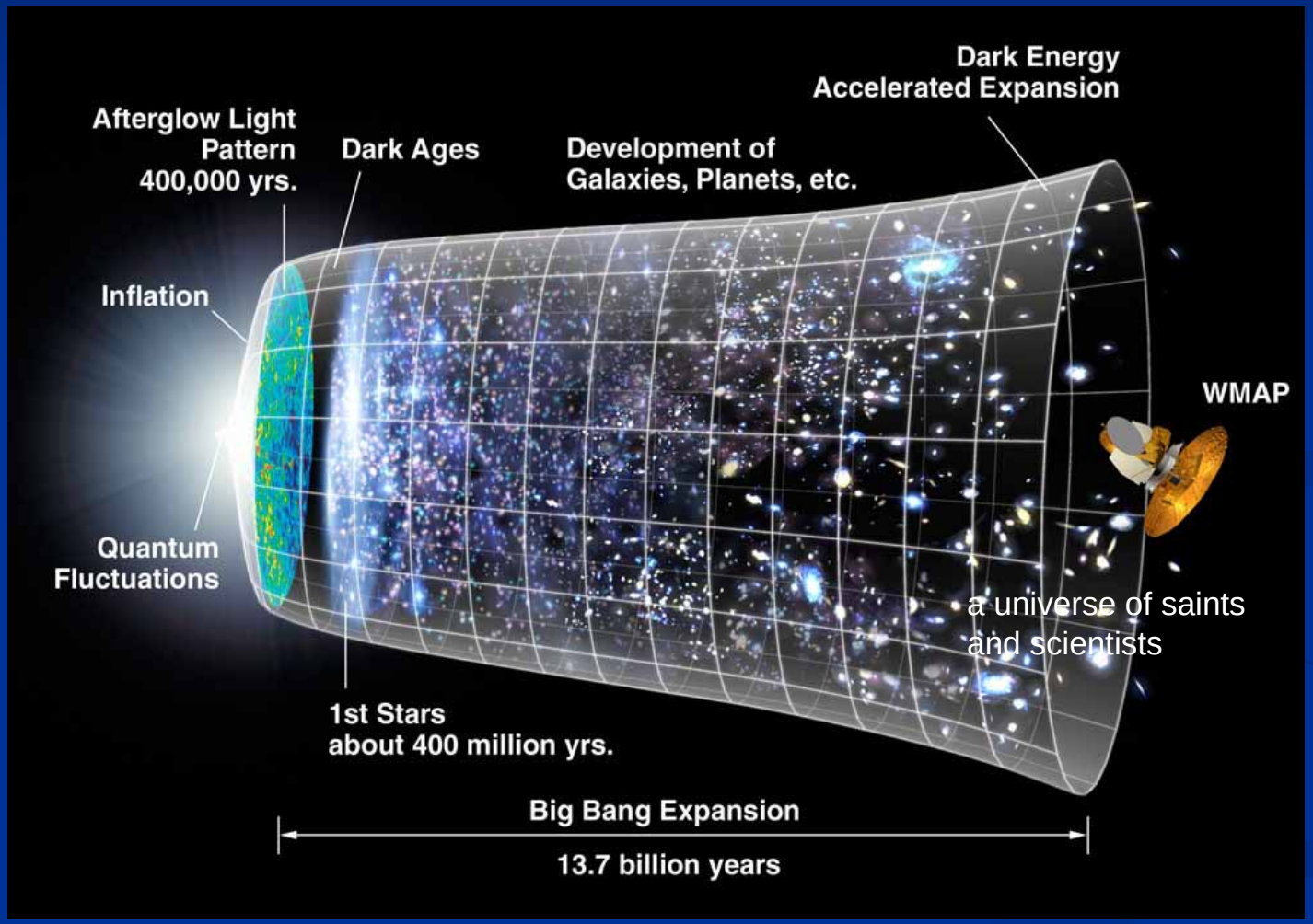
What's Been Going On?



It has evolved through processes involving the fruitful interplay of **chance** (happenstance) and **necessity** (laws, regularity), within a range of potentialities defined by its Creator, and with providential interactions of its Creator through history.

Introduction

What's Been Going On?



Its freedom to make itself necessarily includes the rough edges of **moral and physical evil**, the prices that must be paid for the greater good of **free will** and **free process**

Introduction
Who Are We?

- Today we ask: **“Who are we?”**
- Does science tell us we are merely computers made of meat? Or does science still leave open the possibility we are much more than that?

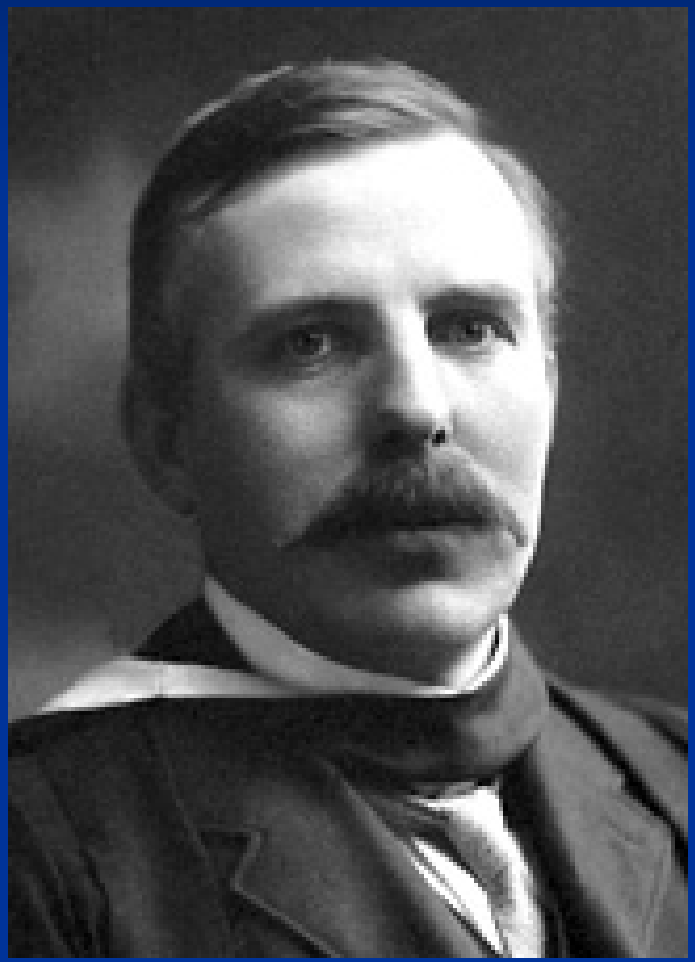
Reductionism vs. Antireductionism

(Anti-) Reductionism

"Nothing Butters"

- Are we merely a complicated arrangement of fundamental particles?
- Does a whole fundamentally reduce to the collection of its parts?
- **Reductionist** or **"Nothing Butters:"** we are *nothing but* a collection of elementary particles.
- **Antireductionist** would disagree: "more is different," the whole is more than simply the sum of its parts.

(Anti-) Reductionism
Physics or Stamp Collecting



Ernest Rutherford
Winner of the Nobel Prize in Chemistry, 1908

"All science is either physics or stamp collecting"

- Ernest Rutherford (1871-1937)

- For a **reductionist**, physics is the fundamental science, and the rest — including biology and life — are only (very complicated) consequences of it

(Anti-) Reductionism
Vitalism

- There are two distinct positions an **antireductionist** can take on why life is fundamentally more than its component particles:
  - 1. **Vitalism**: the position that life involves the infusion of some magical *external* substance or principle that animates it, that makes it "alive"
  - 2. **"Emergence":** the position that new properties emerge *internally* as systems become more and more complicated – properties that would have no meaning in terms of the simple parts by themselves

(Anti-) Reductionism

Vitalism

- There is no support for the view of **vitalism** in science:
  - Biochemistry (the chemistry of life) meets physical chemistry at every point of contact.
  - The evolution of life is a continuous story from the chemically rich shallow pools of early Earth, to the first elementary replicating and living systems, then on through biological evolution to you and me.

(Anti-) Reductionism
Emergence

- There is certainly evidence in science of new properties emerging as a structure grows in complexity, properties that have no meaning in terms of the parts of the structure.
- *Example:* the "wetness" of water.
  - A few molecules of H_20 are not "wet."
  - However, from the interaction of billons of molecules of H_20 emerges a property we experience as "wetness" (which is related to the surface tension of the collection of H_20 molecules).

(Anti-) Reductionism

Emergence

- A much more profound property has emerged in the most complex known structure in the universe, the human brain – **consciousness**.

Consciousness

Consciousness
A Universe Aware of Itself

- Through science we have learned about the remarkable story of the universe's evolution:
  - A hot plasma of quarks and gluons and other elementary particles evolved into a vast world of planets, stars, galaxies, clusters of galaxies, and superclusters.
  - Then life formed out of the chemical soup of a primitive planet Earth, evolved, became more diverse and more complex.
  - Then, with the evolution of human beings, the universe became *aware* of itself.

Consciousness

A Universe Aware of Itself

- Is consciousness to be thought of as a mere superficial “fluff”, a “froth” produced as a side effect of the fundamental reality of the protons, neutrons and electrons arranged in a peculiar array know as the human brain?
- Or is consciousness itself something fundamentally and profoundly new, the greatest achievement of the evolving universe?

Consciousness

The Mystery of the Mind-Brain Problem

- Polkinghorne asserts that **consciousness** remains a profound mystery, and we are no where near solving the **mind-brain problem**.
- Our minds – our awareness, thoughts, wills, experiences of (for example) beauty – are linked in some way to our brains (a hammer blow the head will affirm this).
- but our minds cannot be simply reduced, as reductionists might insist, to the correlated activity of many brain cells.
- Something more mysterious is going on.

Consciousness

The Mystery of the Mind-Brain Problem

- We would all sit up if someone said he could use the power of his thoughts to levitate an inanimate object, say a book.
- We would be less than impressed if he then picked up the book and raised it with his hand
- – yet was that not a levitation by the power of thought?

Consciousness

The Parable of the Chinese Room

- *Thinking exceeds computation*. We are more than computers made of meat.
- Philosopher John Searle made this point in his **Parable of the Chinese Room**
  - You are in an office with two grilles.
  - Through one grille you receive pieces of paper with some Chinese writing on it (but to you, knowing no Chinese, they are just squiggles).
  - You match the squiggles on the paper with squiggles in a book you have been given, and then copy on the paper some squiggles in the book that are beside the match
  - You then hand out the paper through the second grille.

Consciousness

The Parable of the Chinese Room

- The squiggles you were given were questions in Chinese, and the squiggles you copied out from a book were the answers, but you didn't have the slightest idea what was going on.
  - You: were the computer
  - Book: was the program
  - The only *understanding* however was in the person who compiled the book – the programmer
- Computers lack the human capacity for *meaning*.

Consciousness
Glimmers from Science

- Whatever the answer to the mystery of consciousness and the mind-brain problem, there are several glimmers from science that the explanation will not be a reductionist one:
  - the fundamental interconnectedness of physical reality, as found in:
    - Quantum nonlocality = quantum entanglement
    - Chaos theory
  - the nascent science of "Complexity Theory" that raises the possibility that complex structures may:
    - have their own fundamental laws
    - influence their constituent parts (that is, display a "top-down" causality)

Quantum Nonlocality

Quantum Nonlocality

Physical Reality

- Quantum physics tells us that fundamental physical reality is best imagined *not* as a vast number of subatomic particles swirling about, but as a seething bed of unembodied potentially, possibility.
- The boundaries, the range or scope of that potentiality, possibility is encapsulated in the quantum wavefunction or statefunction.

Quantum Nonlocality
Physical Reality

- When a scientists (or any observer) attempts to detect or measure some property of a particle (say its position or speed):
  - **the act of measurement** *causes* the wavefunction of the particle to **collapse**, and
  - the particle comes into existence, becomes embodied with ***one*** of the possible values of the property allowed by its wavefunction.
- The wavefunction can tell the observer the probability of the particle taking on a particular value of the property, but the actual value taken appears to be "chosen" at random by the ground of physical reality.

Quantum Nonlocality

Physical Reality

- *For example:* if we try to measure the position of an electron:
  - the wavefunction of the electron will tell us the *probability* of finding the electron in a given position when we do a measurement, but
  - the actual position taken on by the electron when we collapse the wavefunction by a measurement could be *anywhere* in the range of potentiality / possibility described by its wavefunction.
  - it could be here, it could be there …

Quantum Nonlocality

Physical Reality

- Note:
  - Our inability to exactly predict the position of the electron is *not* due to some experimental error or some imprecision of our measuring tools. It is built into the fabric of reality.
  - The electron does not exist as an embodied particle until we try to measure it, and then it comes into existence in a particular position.
  - Before the measurement, we can only predict the probability of it showing up in that position.

Quantum Nonlocality

Physical Reality

- Once we cease to observe a particle, it soon "disappears" back into the bed of potentiality, possibility described by its wavelength – until someone attempts another measurement on it.
  - In the quantum world of elementary particles, we might say the tree in forest ceases to exist when no one is in the forest to look at it.

Quantum Nonlocality
Physical Reality

- In the macroscopic world, we don't notice this bizarre quantum behavior because everything we look at consists of billions and billions of quantum particles, and their uncertainties cancel out, producing a highly reliable overall pattern of behavior.
  - It is rather like life insurance. By knowing the probabilities of death in someone of a given age, and by insuring a very large number of people, the statistical fluctuations cancel out, and insurers can rely on the calculations of their actuaries to make money.

Quantum Nonlocality

The EPR Experiment

- When two particles interact, their interaction causes them to influence each other even if they subsequent separate
  - In other words: they behave in the future as if the two of them were part of a single wavefunction
- Einstein (along with physicists named Podolsky and Rosen; EPR) proposed a thought experience that had such crazy results he though it would surely prove quantum mechanics wrong.

Quantum Nonlocality

The EPR Experiment

- The EPR thought experiment:
  - Assume electrons have a conserved property “color” that can take on one of two values when a measurement is done to collapse their wavefunction: red or blue.
    - Conserved: the total amount of red or blue must be constant
  - Two electrons interact, one red, one blue.
  - The two electrons then separate. No one is measuring them so they fade back into the realm of possibility, potentiality.
  - A million year later someone tries to measure the color of one of the electrons. The act of measurement causes its wavefunction to collapse. It becomes embodied and takes on one of two possible values of color: red, or blue. Say it become blue.
  - Because color is conserved, *immediately* the color of the other electron – even if it has traveled to the other side of the universe – becomes red.

Quantum Nonlocality

The EPR Experiment

- Einstein: this instantaneous action at a distance is preposterous. How can the two electrons communicate with each other?
- Quantum orthodoxy: by interacting, the two electrons became in some sense a single entity described by a single wavefunction. Their spatial separation does not matter, as their wavefunction exists in the ground of physical reality in a way that is not tied to a particular position or time: it is “nonlocal.”

Quantum Nonlocality

The EPR Experiment

- In 1983, scientists at the University of Paris experimentally confirmed the **EPR effect**, or **quantum nonlocality**.
- Because particles are often interacting, and the "memory" of that interaction is encoded in their wavefunctions, another name for **quantum nonlocality** = the **EPR effect** is **quantum entanglement**.
- **Quantum nonlocality** shows there is an intrinsic interconnectedness in the subatomic world that cannot be broken. Quantum entities are "entangled" with each other, even at vast distances.

Chaos Theory

Chaos Theory
Clocks Versus Clouds

- A profound interconnectedness in physical reality can also be found in the normal "macroscopic" world in **Chaos Theory**.
- Many physical systems are "well-behaved" in that we can easily predict their future behavior. For example: clocks.
- More commonly however physical systems display "chaotic" behavior. For example: clouds.
- "Chaotic" = they are *exquisitely* sensitive to initial conditions.
  - We theoretically have the classical equations to predict their future behavior, but extremely tiny differences in the input values (initial conditions) leads to wildly different behaviors in the future.

Chaos Theory
Clocks Versus Clouds

- *Example:* the weather in North America can be effected by whether or not an African butterfly flapped its wings a week earlier.
- Another name for Chaos Theory: **"The Butterfly Effect"**
- *Example:* analytical calculation of the exact position of each gas particle in a cubic foot of room air after a fraction of a second of motion would require knowledge of initial conditions so infinitesimally precise that we would have to take into account the gravitational effect of an electron at the other end of the universe.

Chaos Theory
Clocks Versus Clouds

- **Chaos Theory** is a “classical” theory. However, the extreme sensitivity to initial conditions means chaos theory cannot ignore the quantum realm, as the knowledge of initial conditions needed often gets to the level of the size of quantum mechanical uncertainty.
  - There is still no satisfactory theory that merges Chaos Theory with quantum mechanics.

Chaos Theory
Clocks Versus Clouds

- **Chaos Theory** = The **Butterfly Effect** does allow us to say that in a world that has more clouds than clocks, there is a profound macroscopic “interconnectedness” that defies a simple reductionist view

“Complexity” Theory

Top – Down Causality

Complexity Theory
More Is Different

- **Complexity theory** is a nascent science looking at the emergence of behavior and properties in complex systems that could not have been recognized from the properties of their constituent parts.
- “More is different.”

Complexity Theory
More Is Different

- *Example:* consider a large array of electric lights:
  - What each bulb does next is determined by the present states of two other bulb in the array.
  - The system is started at some random state of illumination and allowed to evolve.
  - The array will soon "self-organize" into a very orderly set of behaviors, cycling through a very limited set of patterns
    - For 10,000 bulbs, there would be 10^{3000} different states it could theoretically be found it, but it cycles through only 100 (In general, for N bulbs, the number of patterns is $N^{1/2}$)

Complexity Theory
More Is Different

- Similar spontaneous generation of order can be seen in **cellular automata**.
- In chaotic systems in which friction is present, the chaotic system will converge after a period to time onto an intricate but limited portfolio of possible forms called a **"strange attractor"**
  - ("attractor" = the motions converged upon
  - "strange" = refers to the fractal character of its structure in "phase space")

Complexity Theory
More Is Different

- At present, there is no general theory that covers the behavior of complex systems.
- Polkinghorne believes there is a deep theory underlying these phenomenon whose discovery will revolutionize scientific thinking.
- We will have to adopt a new style of thought in science, and treat systems holistically using "information" as a fundamental concept
  - "information" = the specification of patterns of dynamical ordered behavior

Complexity Theory
Top Down Causality

- We may find that in addition to explaining the world with:
  - **“bottom-up” causality**, the way fundamental constituents effect the whole, we need to take into account a:
  - **“top-down” causality**, the way global properties of a complex system effect its constituent parts

Who Are We?

Conclusions

Who Are We?

Inadequacy of a Reductionist View

- What do we make of all this?
- Science is only beginning to try to understand complex systems, and cannot tell us who we are – despite the arrogant (implying knowledge science does not have) claims of some scientists that we are only “computers made of meat”, or “genetic survival machines”

Who Are We?

Inadequacy of a Reductionist View

- The interconnectedness of physical reality found in:
  - **Quantum Nonlocality** and **Chaos Theory**,
- the unexplained self-organization of complex systems just beginning to be studied in **Complexity Theory**
- suggest a reductionist view of who we are will not be adequate.

Who Are We?

Inadequacy of a Reductionist View

- In searching for the answer of who we are, we must resist an impoverished account of human experience.
- We must not ignore the "data" of:
  - The human experience of artists that the world is a carrier of beauty,
  - The human experience of writers that the world is an arena of moral choice and responsibility,
  - The human experience of saints and mystics who testify to encounters with an ultimate Reality both beyond us and yet also nearer to us than breathing.

Who Are We?

Religion as an Explanation for the Richness of Reality

- In seeing the will and nature of the Creator underlying and unifying the varieties of human experience, it makes the richness of human experience more intelligible:
  - Our scientific explorations are insights into the rational order with which God has endowed the universe,
  - Our experiences of beauty are a sharing in God's joy in creation,
  - Our moral perceptions are intuitions of God's good and perfect will,
  - Our religious experiences are encounters with the hidden divine presence.

Who Are We?

Religion as an Explanation for the Richness of Reality

- Such a view is whole and satisfying.
- Who are we? We are God's creatures.

Topics

Quarks, Chaos, and Christianity

- **Jan 6:** Is Anyone There?
- **Jan 13:** What's Been Going On?
- **Jan 20:** *Annual Parish Meeting*
- **Jan 27:** Who are We?
- **Feb 3:** Prayer and Miracles
- **Feb 10:** How Will It End?