I live, when I am writing (which is most of the time), in the attic of a suburban middle-class house that is rather on the modest side, but is reasonably comfortable.

I am solvent, always have been, and with reasonable luck, always will be, for I am generously paid for doing what I most want to do in the world. My scale of living is not lavish, for there's nothing much I want out of life beyond a working electric typewriter and a steady stream of blank paper; but what I want, I have, or can get.

I have no boss and no employees, so I am my own master in both directions. My editors are (and always have been) so considerate of my feelings as never to give me a cross word. I am in no trouble with the authorities and (again with reasonable luck) hope never to be.

In short, I live, immersed in my work and in my content, in the richest nation on Earth, in the period of that nation's maximum power.

What a pity, then, that it is all illusion and that I cannot blind myself to the truth. My island of comfort is but a quiet bubble in a torrent that is heaving its way downhill to utter catastrophe. I see nothing to stand in its way and can only watch in helpless horror.

The matter can be expressed in a single word: Population.

There are many who mean about the "population explosion" but they are rarely specific and their worry is easily shrugged away by the comfortable and indifferent. Population has always been expanding, it would seem, and the standard of living has gone up with it, hasn't it?

After all, more hands and more minds mean more cooperation and more inventiveness, and therefore more progress. A million men can do more than a hundred men can, and their added abilities more than make up for the added difficulties introduced by the interactions of a million rather than a hundred.

And the proof rests in the results. The population of the Earth in 1969 is estimated to be 3,500,000,000 which is far higher than it has ever been in history. Yet the overall standard of living on Earth in 1969 is also far higher than it has ever been in history. This is not to say there aren't hundreds of millions who are constantly hungry; hundreds of millions who are downtrodden, frightened, and enslaved—but in the past it has always been even worse.

Well, then, what are we worried about? Why may we not expect that population and living standard will continue to rise, hand in hand?

That sort of outlook reminds me of the tale of the man who fell off the Empire State Building. As he passed the tenth story, he was heard to mutter, "Well, I've fallen ninety stories and I'm all right so far."

Suppose we look at the history of the Earth's population, gathering the best estimates we can find.

Ecologists feel that the preagricultural food supply—obtainable by hunting, fishing, collecting wild fruit and nuts, and so on—could not support a world population of more than twenty million; and in all likelihood the actual population during the Stone Age was never more than a third or half of this at most.

This means that as late as 6600 B.C., the world population could not have numbered more than six to ten million people—roughly the population of New York, Shanghai, or Tokyo today. (When America was discovered, the food-gathering Indians, occupying what is now the United States, probably numbered not much more than 250,000, which is like imagining the population of Dayton, Ohio, spread out over the nation.)

The first big jump in world population came with the introduction of agriculture, when the river civilizations along the Nile, the Tigris-Euphrates and the Indus began, by dint of irrigation, to grow food in quantity rather than to gather it. This made possible the establishment of a much denser population than had hitherto been able to exist in those areas.

The increase of population, thereafter, paralleled the opening of new lands to agriculture. By the beginning of the Bronze Age, the
world population may have been twenty-five million; by the beginning of the Iron Age, seventy million.

At the time of the start of the Christian era, world population may have been about 150 million, with one third concentrated in the Roman Empire, another third in the Chinese Empire, and the rest scattered over the rest of the world.

The fall of the Roman Empire meant a local decline of population but the worst of the effects was concentrated in Western Europe and it is doubtful if the world population went down much, if at all. Furthermore, by the year 1000, the invention of the horseshoe, the horse collar and the mold-board plow had made the horse an efficient farm animal so that the cold, damp forest land of northwestern Europe could be cleared and turned to agriculture. By 1600, the world population stood at five hundred million.

European explorers opened up 18,000,000 square miles of new land in the Americas and elsewhere and the Industrial Revolution mechanized agriculture, so that the necessary proportion of farmers to non-farmers began to drop. Agriculture could support more and more people per acre of farm land. By 1800, world population was 300 million; by 1900, it was 1,600 million; by 1950, it was 2,500 million; and by 1969 it is, as aforesaid, 3,500 million.

Looking at these figures, let's consider the length of time it takes to double the Earth population.

Up through A.D. 100, the Earth's population doubled, on the average, every 1,400 years. This is an extremely slow rate of doubling when you consider that if every married couple has four children and then dies, the Earth's population would double in a single generation of, say, thirty-three years. Can it be that our prehistoric and ancient ancestors didn't know how to go about having children?

Of course not. They had children with all the facility we display today. The trouble is that most of the children died before their fifth birthday. Growing to maturity was a comparative rarity and even those who made it were lucky if they lived the aforesaid thirty-three years. Life was hard and bitter then, and death was always present.

The inexorable shortness of life is clearly recorded in world literature, but times have changed and we forget and misinterpret.

In the Iliad, Homer speaks of Nestor who "outlived two whole generations of his subjects, and was ruling over a third." Naturally, we think of him as an ancient, ancient man—but he wasn't. He was probably about sixty; that would have been long enough to bury almost every father and son in his kingdom and to be ruling over grandsons.

Most early societies were ruled by "elders" of one sort or another. The Romans had their "Senate," which is simply from a Latin word meaning "old" so that a Senator is a Latinized elder. The feeling now, therefore, is that these societies were run by senile (same root as senator) graybeards.

Nonsense! In an early society, anyone who made it past thirty-five was an "elder." If you want some interesting corroboration of that, just remember that membership in our own club of ruling elders, the United States Senate, requires a minimum age of thirty. To the founding fathers in 1787, this seemed quite old enough for the purpose. If we were starting from scratch today, I'll bet we would have set the minimum at forty, at least.

Even in Shakespeare's time, the notions of old age were not like ours. Richard II begins with the wonderful line: "Old man of Gaunt, time-honored Lancaster," so that old Gaunt is invariably presented in any production of the play as a man of about 150, who can just manage to hobble across the stage. Actually, at the time the play opened, good old time-honored Lancaster was fifty-eight years old.

You may think that Shakespeare didn't happen to know that. Well, then, in King Lear, the Duke of Kent describes himself at one point by saying, "I have years on my back forty-eight," and then later on in the play he is referred to as an "ancient ruffian."

We can see, then, why the first divine command to mankind which is recorded in the Bible is "Be fruitful, and multiply, and replenish the earth . . ." (Genesis 1:28).

If, under ancient conditions, man was not fruitful, he would not multiply. Only by having as many children as possible could he rely on a few surviving long enough to have children of their own.

But times have changed! The earth is replenished and it is no longer necessary to be endlessly fruitful in order to have a few survive. Those who take these words of the Bible, applicable to one set of conditions, and who insist on applying them literally to a completely altered set of conditions are doing mankind an enormous disservice. If I spoke in theological terms, I would say they were doing the Devil's work.
As conditions improved and as the death rate fell somewhat while life expectancy lengthened, the time required to double the Earth's population grew shorter. Here are my estimates for the "doubling time" at various stages in history:

<table>
<thead>
<tr>
<th>Year Range</th>
<th>Doubling Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to A.D. 100</td>
<td>1400 years</td>
</tr>
<tr>
<td>100-A.D. 1600</td>
<td>900 years</td>
</tr>
<tr>
<td>1600-A.D. 1800</td>
<td>250 years</td>
</tr>
<tr>
<td>1800-A.D. 1900</td>
<td>90 years</td>
</tr>
<tr>
<td>1950-A.D. 1969</td>
<td>75 years</td>
</tr>
</tbody>
</table>

You see, then, that it is not merely that the population is increasing that is the worst of it; it is that the rate at which population is increasing is itself increasing. That is what makes the situation explosive. And the situation is worse in those areas where it can least afford to be bad. In the Philippine Islands, the current rate of increase implies a doubling time of only twenty-two years.

This decrease in doubling time has been brought about by an unbalanced decrease in the death rate. Birth rates have gone down, too, but not nearly enough to compensate and they have gone down least in the "underdeveloped" portions of the Earth.

What can we do now?
In order to make some decision, let's get one thing clear. The situation cannot be allowed to continue. I don't mean that the doubling time must not be allowed to continue decreasing. It's worse than that. Doubling time must not even be allowed to stay where it is.

Oh, there are optimists (and in this connection I find it hard to refer to them by that word; I prefer to think of them as idiots) who think that if we only end wars, establish world tranquillity and advance science we can absorb population increase. We need only farm scientifically, make intelligent use of fertilizers, put the ocean to efficient use as a source of food and fresh water and minerals, develop fusion power, harness the Sun— Then we can easily support a much larger population than now exists. I have seen statements to the effect that the Earth, Utopically run, could support fifty billion human beings in comfort.

But then what? What's to prevent the population from increasing beyond that? Would not some form of birth control be required then? In other words, the greatest optimist cannot deny the necessity of birth control eventually; he merely says, "Not yet!"

Is it possible that such an optimist has a dim idea that the time when the Earth's population will reach fifty billion (or whatever generous limit he sets) is so far off that no one need worry now? Or, worse yet, does he have the idea that by the time fifty billion is reached, further scientific advance will make it possible to support still higher numbers and so on into the indefinite future?

If that is so, then the optimist hasn't the faintest idea of the power of a geometric progression. But then, hardly anyone does. Let's see if we can't illustrate that power.

Since the Earth's population is 3.5 billion people and since that population is now doubling at the rate of once every forty-seven years, we can make use of the following equation:

\[
(3,500,000,000) 2^{x/47} = y \tag{Equation 1}
\]

This tells us the number of years (x) it will take us to reach a world population of y, supposing that the doubling rate remains absolutely constant. Solving for x in Equation 1, we get:

\[
x = 156 (\log y - 9.54) \tag{Equation 2}
\]

Suppose we ask ourselves, now, how long it will be before we reach that population of fifty billion that optimists think Earth can support provided only we establish a Utopia?

Well, if y is set at 50,000,000,000, then \( \log y \) is 10.70 and x is equal to 182 years.

In other words, if the doubling rate continues exactly as now, we will have reached a world population of 50,000,000,000 by A.D. 2131.

The wildest optimism is required if you think that in the space of time in which the American Constitution has thus far existed (six generations) we are going to be able to abolish war and establish the kind of rational Utopia which would make so large a population possible and comfortable.

Even then, we would be much nearer a colossal catastrophe in case anything happened to go wrong with fifty billion people encumbering the Earth than the present 3.5 billion. And what if population
continued to increase even past the fifty billion mark? Could we still rely on science to continue to make higher populations possible. How high can populations go in the reasonable future?

Let’s move on and see—

The island of Manhattan has an area of 22 square miles and a population of 1,750,000. In the middle of the working day, when people come to Manhattan from adjoining areas, the population jumps to 2,200,000 at least; at which time the population density is 100,000 people per square mile.

Suppose all the Earth were covered with people as thickly as Manhattan is at lunchtime. Suppose the Sahara Desert were covered that thickly, and the Himalayan Mountains, and Greenland and Antarctica and everywhere else. Suppose we threw planks over all the oceans and crowded those planks like a Manhattan lunch hour as well.

The Earth’s total surface area is 200,000,000 square miles. If all of it were populated at Manhattan density, the world population would be 20,000,000,000,000, or 20 trillion. How long, now, would it take to reach that figure?

As Equation 2 would tell you, the answer is the astonishingly small one of 585 years. By A.D. 2554, at the present rate of increase, Earth’s surface will become one huge Manhattan.

Of course, you may decide not to let me get away with that. I am, after all, a science fiction writer at times, and I know all about space travel. Surely by A.D. 2554 men will be flitting all over the solar system and will therefore be able to populate the planets, which then will be able to absorb some of the population excess from Earth.

Sorry, but that’s not good enough. In the next 47 years, we would have to export 3.5 billion people to the Moon and Mars and wherever, just in order to stay where we are now on Earth. Is there anyone here who thinks we can do that in 47 years? Is there anyone here who thinks the Moon and Mars and wherever can be engineered to support 3.5 billion people in the next 47 years even if we could get them there?

In fact, let’s go further. There are about 135,000,000,000 stars in the Galaxy. Some of them may have habitable planets in the sense that men could live on them without prohibitive engineering.

Of course, we can’t reach such planets, either now or in the foreseeable future, but suppose we could. Suppose we could transfer human beings instantaneously to any planet we wished by a mere snap of the fingers and with no further expenditure of energy than that. And suppose that there was an incredible wealth of habitable planets in the Galaxy; suppose that every single star in the Galaxy had ten such planets. There would then be 1,350,000,000,000 habitable planets in the Galaxy.

Suppose further that the same were true of every other galaxy and that (as some estimate) there are a hundred billion such galaxies in existence. This means there would be 135,000,000,000,000,000,000,000,000,000,000 or 2.7 trillion, trillion trillion.

How long would it take us to reach such a population, eh? Now that we are talking of trillions of trillions of trillions of people, it might seem that we can wait many millions of years to fill the Universe in this impossible way. If you think so, you still don’t understand the power of a geometric progression.

At the present rate of population increase, it will take us only 4200 years to reach a population of 2.7 trillion trillion trillion. By A.D. 6170, we will have crowded the Universe from end to end with people. Every star in every galaxy will see each of its ten planets carrying a population that will resemble a Manhattan lunch hour on every part of its surface.

Do you think I can’t get any more extreme? Suppose man’s scientific advance managed to turn all the Universe into food and to tap hyperspace for energy. How long would it take for the entire mass of the known Universe to be turned into human flesh and blood? The Sun has a mass of 4.4 million trillion trillion pounds. Estimate the average weight of a human being at 110 pounds and you find that if the Sun were converted into people, it would make up a population of 40,000 trillion trillion.

Multiply that by 135 billion to convert the Galaxy into people; multiply that again by 100 billion to convert all the galaxies into people; multiply that again by 100 to account for the dust and debris that exist in the Universe outside the stars and the total mass of the Universe converted into people makes for a population of
be supported on Earth. Every time the human population increases in mass by one ton, the mass of non-human animal life must decrease by one ton to make room.

How long then, will it take the human race to increase to the point where its mass is equal to the maximum mass that animal life may have? The answer is 624 years. In other words, by the time all the Earth is Manhattanized, we will have had to kill off just about all of animal life. All the remaining wild life will be gone. All the fish in the sea, all the birds in the sky, all the worms underground; even all our own domestic animals and pets, from horses and cattle to cats, dogs and parakeets, will have to go, sacrificed at the altar of human procreation.

(Think of that, you conservationists, and remind yourselves frequently that while human population increases, animal life must dwindle and not all your piety, wit or tears can do anything about it. If you want to fight the good fight for conservation, fight the better fight for population control.)

What’s more, killing off animals is only part of it. All plant life would have to be converted into food plants, with as little non-food portion as possible. In the day when the Earth becomes one large Manhattan—one large planet-grilling office building—the only living things on Earth other than human beings will be those little cells in the algae tanks all over the roof of that building.

Theoretically, we could learn to utilize solar energy and convert it into synthetic food without the intervention of plants, but do you think we can work this out at a level necessary to support a population of twenty trillions within the next five or six centuries? I don’t.

Nor is it only a matter of food. What about resources? Already, with a population of 3.5 billion and the present level of technology, we are eroding our soil, spreading our minerals thin, destroying our forests, and consuming irreplaceable coal and oil at a fearful rate. Remember, that as the population increases, the level of technology and therefore the consumption of resources increase even faster.

And what about pollution? Already, with a population of 3.5 billion and the present level of technology, we are poisoning the land, sea and air to a dangerous extent. What will we be doing in a century when the population is 14 billion?

These problems are perhaps not insoluble if we let them grow
no worse, but they would ever then be soluble only with great
difficulty. How will they be solved if the resource expenditure and
the waste production grow worse with each year, as they are doing
and will continue to do.

Finally, what of human dignity? How decently can we live when
crowds of human beings and their tools clog every highway, every
street, every building, every piece of land? The human friction that
results when space disappears and privacy is destroyed makes itself
evident in increasing discontents and hatreds, and this friction will
grow phenomenally worse as the population continues to multiply.

No, take it all in all, I don’t see how we can face let mankind
increase at its present rate for even a single additional generation.
We must reach a population plateau in the early decades of the
twenty-first century.

And I’m sure we will, one way or another. If we do nothing
but what comes naturally, the population increase will be brought
to a halt by an inevitable rise in the death rate through the wars
and civil rioting that worsening human friction and desperation
will bring; through the epidemics that crowding and technological
breakdown will bring; and through the famines that food shortage
will bring.

The reasonable alternative is to reduce the birth rate. That, too,
will fall, naturally, when crowding and starvation make human
procreation less efficient, but do we want to wait for that? If we
wait for that, the famines will start in places like India and Indonesia
(I predict) by 1980.

Let me summarize as bluntly as possible. There is a race in man’s
future between a death-rate rise and a birth-rate decline and by
2000, if the latter doesn’t win, the former will.

I love people, I really do, and yet, in viewing the future, I am
forced to be guided by a certain cynicism because so many people,
however lovable, seem immune to reason.

Several years ago, for instance, at some gathering, a Jewish
woman argued, with considerable emotion, that she could never
feel real confidence in the good will of Gentiles because they had
stood aside and allowed Nazi Germany to torture and kill Jews by
the millions without ever really doing anything about it.

I could appreciate her feeling, being Jewish myself, but didn’t
share them. To make my point, I asked her quietly, “What are you
doing about Negro civil rights?”

And she answered sharply (and rather as I expected), “Let’s
solve our own problems before we take on those of other people.”

But I had not made my point after all for—would you believe
it—there turned out to be no way in which I could convince her of
the inconsistency in her position.

But we have to take people as they are; complete with their
aversion to the rational; and face, in these last decades of the
twentieth century, the most crucial problem mankind has ever had
to deal with. It is the question of sheer survival; not for this
sect or that, this nation or that, this political or economic doctrine
or that—but, quite simply, for civilization generally.

And maybe even for mankind generally.

And maybe even for multicellular life generally.

The prime problem is that of increasing population, something
I considered forcefully in the previous chapter, and am taking up
even more forcefully in this final chapter. Even if, right now as
of this minute, the population of Earth levels off, we still face
an overwhelming problem. The population of Earth is already too
high for survival, for we grow in other ways than mere numbers.
I live, when I am writing (which is most of the time), in the attic of a suburban middle-class house that is rather on the modest side, but is reasonably comfortable.

I am solvent, always have been, and with reasonable luck, always will be, for I am generously paid for doing what I most want to do in the world. My scale of living is not lavish, for there's nothing much I want out of life beyond a working electric typewriter and a steady stream of blank paper; but what I want, I have, or can get.

I have no boss and no employees, so I am my own master in both directions. My editors are (and always have been) so considerate of my feelings as never to give me a cross word. I am in no trouble with the authorities and (again with reasonable luck) hope never to be.

In short, I live, immersed in my work and in my content, in the richest nation on Earth, in the period of that nation's maximum power.

What a pity, then, that it is all illusion and that I cannot blind myself to the truth. My island of comfort is but a quiet bubble in a torrent that is heaving its way downhill to utter catastrophe. I see nothing to stand in its way and can only watch in helpless horror.

The matter can be expressed in a single word: Population. There are many who moan about the "population explosion" but they are rarely specific and their worry is easily shrugged away by the comfortable and indifferent. Population has always been expanding, it would seem, and the standard of living has gone up with it, hasn't it?

After all, more hands and more minds mean more cooperation and more inventiveness, and therefore more progress. A million men can do more than a hundred; men can, and their added abilities more than make up for the added difficulties introduced by the interactions of a million rather than a hundred.

And the proof rests in the results. The population of the Earth in 1969 is estimated to be 3,500,000,000 which is far higher than it has ever been in history. Yet the overall standard of living on Earth in 1969 is also far higher than it has ever been in history. This is not to say there aren't hundreds of millions who are constantly hungry; hundreds of millions who are downtrodden, frightened, and enslaved—but in the past it has always been even worse.

Well, then, what are we worried about? Why may we not expect that population and living standard will continue to rise, hand in hand?

That sort of outlook reminds me of the tale of the man who fell off the Empire State Building. As he passed the tenth story, he was heard to mutter, "Well, I've fallen ninety stories and I'm all right so far."

Suppose we look at the history of the Earth's population, gathering the best estimates we can find.

Ecologists feel that the preagricultural food supply—obtainable by hunting, fishing, collecting wild fruit and nuts, and so on—could not support a world population of more than twenty million; and in all likelihood the actual population during the Stone Age was never more than a third or half of this at most.

This means that as late as 6000 B.C., the world population could not have numbered more than six to ten million people—roughly the population of New York, Shanghai, or Tokyo today. (When America was discovered, the food-gathering Indians, occupying what is now the United States, probably numbered not much more than 250,000, which is like imagining the population of Dayton, Ohio, spread out over the nation.)

The first big jump in world population came with the introduction of agriculture, when the river civilizations along the Nile, the Tigris-Euphrates and the Indus began, by dint of irrigation, to grow food in quantity rather than to gather it. This made possible the establishment of a much denser population than had hitherto been able to exist in those areas.

The increase of population, thereafter, paralleled the opening of new lands to agriculture. By the beginning of the Bronze Age, the
world population may have been twenty-five million; by the beginning of the Iron Age, seventy million.

At the time of the start of the Christian era, world population may have been about 150 million, with one third concentrated in the Roman Empire, another third in the Chinese Empire, and the rest scattered over the rest of the world.

The fall of the Roman Empire meant a local decline of population but the worst of the effects was concentrated in Western Europe and it is doubtful if the world population went down much, if at all. Furthermore, by the year 1000, the invention of the horseshoe, the horse collar and the mold-board plow had made the horse an efficient farm animal so that the cold, damp forest land of Northwestern Europe could be cleared and turned to agriculture.

By 1600, the world population stood at 135 million.

European explorers opened up 18,000,000 square miles of new land in the Americas and elsewhere and the Industrial Revolution mechanized agriculture, so that the necessary proportion of farmers to non-farmers began to drop. Agriculture support more and more people per acre of farm land. By 1800, world population support more and more people per acre of farm land. By 1800, world population was about 250 million.

In the 17th and 18th centuries, the world population stood at 700 million. As a result, the world population doubled in the 18th and 19th centuries.

The figure is 1.8 billion by the year 2000, and by the year 2100, it is likely to be 3.6 billion. According to the projections, the world population may reach 10 billion by the year 2200. The exponential growth of the world population is a profound social and environmental phenomenon.

In the 20th century, world population doubled in the second half of the century. This growth was driven by improvements in health and sanitation, leading to a dramatic decline in child mortality rates.

The world population is projected to reach 9.7 billion by 2050. The next billion people will be added during this century, reflecting the continued growth in developing countries.

The rapid growth in the world population has significant implications for food security, natural resources, and the environment. It is crucial to address these challenges through sustainable development and effective policies.
As conditions improved and as the death rate fell somewhat while life expectancy lengthened, the time required to double the Earth’s population grew shorter. Here are my estimates for the “doubling time” at various stages in history:

<table>
<thead>
<tr>
<th>Period</th>
<th>Doubling Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to A.D. 100</td>
<td>1400 years</td>
</tr>
<tr>
<td>100–A.D. 1600</td>
<td>900 years</td>
</tr>
<tr>
<td>1600–A.D. 1800</td>
<td>250 years</td>
</tr>
<tr>
<td>1800–A.D. 1900</td>
<td>90 years</td>
</tr>
<tr>
<td>1900–A.D. 1950</td>
<td>75 years</td>
</tr>
<tr>
<td>1950–A.D. 1969</td>
<td>47 years</td>
</tr>
</tbody>
</table>

You see, then, that it is not merely that the population IS increasing that is the worst of it; it is that the rate at which population is increasing is itself increasing. That is what makes the situation explosive. And the situation is worse in those areas where it can least afford to be bad. In the Philippine Islands, the current rate of increase implies a doubling time of only twenty-two years.

This decrease in doubling time has been brought about by an unbalanced decrease in the death rate. Birth rates have gone down, too, but not nearly enough to compensate and they have gone down least in the “underdeveloped” portions of the Earth.

What can we do now?

In order to make some decision, let’s get one thing clear. The situation cannot be allowed to continue. I don’t mean that the doubling time must not be allowed to continue decreasing. It’s worse than that. Doubling time must not even be allowed to stay where it is.

Oh, there are optimists (and in this connection I find it hard to refer to them by that word; I prefer to think of them as idiots) who think that if only we end wars, establish world tranquility and advance science we can absorb population increase. We need only farm scientifically, make intelligent use of fertilizers, put the ocean to efficient use as a source of food and fresh water and minerals, develop fusion power, harness the Sun—Then we can easily support a much larger population than now exists. I have seen statements to the effect that the Earth, Utopically run, could support fifty billion human beings in comfort.

But then what? What’s to prevent the population from increasing beyond that? Would not some form of birth control be required then? In other words, the greatest optimist cannot deny the necessity of birth control eventually; he merely says, “Not yet!”

Is it possible that such an optimist has a dim idea that the time when the Earth’s population will reach fifty billion (or whatever generous limit he sets) is so far off that no one need worry now? Or, worse yet, does he have the idea that by the time fifty billion is reached, further scientific advance will make it possible to support still higher numbers and so on into the indefinite future?

If that is so, then the optimist hasn’t the faintest idea of the power of a geometric progression. But then, hardly anyone does. Let’s see if we can’t illustrate that power.

Since the Earth’s population is 3.5 billion people and since that population is now doubling at the rate of once every forty-seven years, we can make use of the following equation:

\[
(3,500,000,000) 2^{x/47}=y \tag{Equation 1}
\]

This tells us the number of years \(x\) it will take us to reach a world population of \(y\), supposing that the doubling rate remains absolutely constant. Solving for \(x\) in Equation 1, we get:

\[
x=156 (\log y −9.54) \tag{Equation 2}
\]

Suppose we ask ourselves, now, how long it will be before we reach that population of fifty billion that optimists think Earth can support provided only we establish a Utopia?

Well, if \(y\) is set at 50,000,000,000, then \(\log y = 10.70\) and \(x\) is equal to 182 years.

In other words, if the doubling rate continues exactly as now, we will have reached a world population of 50,000,000,000 by A.D. 2151.

The wildest optimism is required if you think that in the space of time in which the American Constitution has thus far existed (six generations) we are going to be able to abolish war and establish the kind of rational Utopia which would make so large a population possible and comfortable.

Even then we would be much nearer a colossal catastrophe in case anything happened to go wrong with fifty billion people encumbering the Earth than the present 3.5 billion. And what if population
continued to increase even past the fifty billion mark? Could we still rely on science to continue to make higher populations possible. How high can populations go in the reasonable future?

Let's move on and see-

The island of Manhattan has an area of 22 square miles and a population of 1,750,000. In the middle of the working day, when people come to Manhattan from adjoining areas, the population jumps to 2,200,000 at least; at which time the population density is 100,000 people per square mile.

Suppose all the Earth were covered with people as thickly as Manhattan is at lunchtime. Suppose the Sahara Desert were covered that thickly, and the Himalayan Mountains, and Greenland and Antarctica and everywhere else. Suppose we threw planks over all the oceans and crowded those planks like a Manhattan lunch hour as well.

The Earth's total surface area is 200,000,000 square miles. If all of it were populated at Manhattan density, the world population would be 20,000,000,000,000, or 20 trillion. How long, now, would it take to reach that figure?

As Equation 2 would tell you, the answer is the astonishingly small one of 585 years. By A.D. 2554 at the present rate of increase, Earth's surface will become one huge Manhattan.

Of course, you may decide not to let me get away with that. I am, after all, a science fiction writer at times, and I know all about space travel. Surely by A.D. 2554 men will be flitting all over the solar system and will therefore be able to populate the planets, which then will be able to absorb some of the population excess from Earth.

Sorry, but that's not good enough. In the next 47 years, we would have to export 3.5 billion people to the Moon and Mars and wherever, just in order to stay where we are now on Earth. Is there anyone here who thinks we can do that in 47 years? Is there anyone here who thinks the Moon and Mars and wherever can be engineered to support 3.5 billion people in the next 47 years even if we could get them there?

In fact, let's go further. There are about 135,000,000,000 stars in the Galaxy. Some of them may have habitable planets in the sense that men could live on them without prohibitive engineering.

Of course, we can't reach such planets, either now or in the foreseeable future, but suppose we could. Suppose we could transfer human beings instantaneously to any planet we wished by a mere snap of the fingers and with no further expenditure of energy than that. And suppose that there was an incredible wealth of habitable planets in the Galaxy; suppose that every single star in the Galaxy had ten such planets. There would then be 1,350,000,000,000,000,000,000 habitable planets in the Galaxy.

Suppose further that the same were true of every other galaxy and that (as some estimate) there are a hundred billion such galaxies in existence. This means there would be 135,000,000,000,000,000,000,000,000,000,000,000,000 habitable planets altogether.

Finally, what if we continued snapping fingers and transferring people until every one of these planets was populated to Manhattan density. The total population of the Universe would then be 2,7 trillion trillion trillion.

How long would it take us to reach such a population, eh? Now that we are talking of trillions of trillions of people, it might seem that we can wait many millions of years to fill the Universe in this impossible way. If you think so, you still don't understand the power of a geometric progression.

At the present rate of population increase, it will take us only 4200 years to reach a population of 2.7 trillion trillion trillion. By A.D. 6170, we will have crammed the Universe from end to end with people. Every star in every galaxy will see each of its ten planets, carrying a population that will resemble a Manhattan rush hour on every part of its surface.

Do you think I can't get any more extreme? Suppose man's scientific advance managed to turn all the Universe into food and to tap hyperspace for energy. How long would it take for the entire mass of the known Universe to be turned into human flesh and blood? The Sun has a mass of 4.4 million trillion trillion pounds. Estimate the average weight of a human being at 110 pounds and you find that if the Sun were converted into people, it would make up a population of 40,000 trillion trillion.

Multiply that by 135 billion to convert the Galaxy into people; multiply that again by 100 billion to convert all the galaxies into people; multiply that again by 100 to account for the dust and debris that exist in the Universe outside the stars and the total mass of the Universe converted into people makes for a population of
54,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,000,-
000, or 54,000 trillion trillion trillion trillion.

How long will it take our progression to reach that? By now,
you should have no high hopes. It will take 6700 years. By the year
A.D. 8700, we will have run completely out of Universe and that's
all there is to it,

Science, in other words, cannot keep up with population for very
long no matter what it does.

It's an absolute certainty that we are not going to multiply at our
present rate till we consume the entire Universe or even till we
merely fill the surfaces of all the planets. I think you will agree that
the extreme of optimism will not carry us past the conversion of
Earth itself into one big Manhattan. This means we have as our
outside limit, the year A.D. 2554. We have only a little over five and
a half centuries left us.

Whatever happens to make the rate of population increase smaller,
or abolish it altogether and give us a stable population, must happen
before A.D. 2554. I don't say "should" or "ought to" or "might," I
very deliberately say "must."

But do we really even have that much time? What does a planet-
wide Manhattan mean?

The total mass of living objects on Earth is estimated at 20
trillion tons, while the present mass of humanity on Earth is about
200 million tons. This means that humanity makes up 1/100,000 of
the total mass of life on Earth. That's pretty good for a single
species

1/100 of life is supported by plant photosynthesis (with some in-
significant bacterial exceptions). Animals can only survive by raid-
ing the chemical energy (food) built up by plants out of solar
energy, even those animals who eat animals only live because the eu-
en animals ate plants, or if they ate animals, too, then those
animals ate plants. However far the chain extends it comes to plants
in the end.

It is estimated that the total mass of an eater in a food chain
must be only one tenth the total mass of the eaten if both are to
survive at a stable population level. This means that all of animal
life has a mass of 2 trillion tons and the mass of humanity is
1/10,000 of that.

Since radiation from the Sun is a fixed quantity and the effi-

cyency of photosynthesis, is also fixed, only so much animal life can

be supported on Earth. Every time the human population increases
in mass by one ton, the mass of non-human animal life must decrease
by one ton to make room.

How long then, will it take the human race to increase to the
point where its mass is equal to the maximum mass that animal
life may have? The answer is 624 years. In other words, by the time
all the Earth is Manhattanized, we will have had to kill off just
about all of animal life. All the remaining wild life will be gone.
All the fish in the sea, all the birds in the sky, all the worms
underground; even all our own domestic animals and pets, from
horses and cattle to cats, dogs and parakeets, will have to go,
sacrificed at the altar of human procreation.

(Think of that, you conservationists, and remind yourselves
frequently that while human population increases, animal life must
dwindle and not all your piety, wit or tears can do anything
about it. If you want to fight the good fight for conservation, fight
the better fight for population control.)

What's more, killing off animals is only part of it. All plant life
would have to be converted into food plants, with as little non-food
portion as possible. In the day when the Earth becomes one large
Manhattan—one large planet-girdling office building—the only living
things on Earth other than human beings will be those little cells
in the algae tanks all over the roof of that building.

Theoretically, we could learn to utilize solar energy and convert
it into synthetic food without the intervention of plants, but do
you think we can work this out at a level necessary to support a
population of twenty trillions within the next five or six centuries?
I don't.

Nor is it only a matter of food. What about resources? Already,
with a population of 3.5 billion and the present level of technology,
we are eroding our soil, spreading our minerals thin, destroying
our forests, and consuming irreplaceable coal and oil at a fearful
rate. Remember, that as the population increases, the level of
technology and therefore the consumption of resources increase even
faster.

And what about pollution? Already, with a population of 3-5
billion and the present level of technology, we are poisoning the
land, sea and air to a dangerous extent, What will we be doing in
a century when the population is 14 billion?

These problems are perhaps not insoluble if we let them grow
no worse, but they would even then be soluble only with great
difficulty. How will they be solved if the resource expenditure and
the waste production grew worse with each year, as they are doing
and will continue to do.

Finally, what of human dignity? How decently can we live when
crowds of human beings and their tools clog every highway, every
street, every building, every piece of land? The human friction that
results when space disappears and privacy is destroyed makes itself
evident in increasing discontentants, and hatreds, and this friction will
grow phenomenally worse as the population continues to multiply.

No, take it all in all, I don't see how we can dare let mankind
increase at its present rate for even a single additional generation.
We must reach a population plateau in the early decades of the
twenty-first century.

And I'm sure we will, one way or another. If we do nothing
but what comes naturally, the population increase will be brought
to a halt by an inevitable rise in the death rate through the wars
and civil rioting that worsening human friction and desperation
will bring; through the epidemics that crowding and technological
breakdown will bring; and through the famines that food shortage
will bring.

The reasonable alternative is to reduce the birth rate. That, too,
will fall, naturally, when crowding and starvation make human
procreation less efficient, but do we want to wait for that? If we
wait for that, the famines will start in places like India and Indonesia
(I predict) by 1980.

Let me summarize as bluntly as possible. There is a race in man's
future between a death-rate rise and a birth-rate decline and by
2000, if the latter doesn't win, the former will.

I love people, I really do, and yet, in viewing the future, I am
forced to be guided by a certain cynicism because so many people,
however lovable, seem immune to reason.

Several years ago, for instance, at some gathering, a Jewish
woman argued, with considerable emotion, that she could never
feel real confidence in the good will of Gentiles because they had
stood aside and allowed Nazi Germany to torture and kill Jews by
the millions without ever really doing anything about it.

I could appreciate her feeling, being Jewish myself, but didn't
share them. To make my point, I asked her quietly, "What are you
doing about Negro civil rights?"

And she answered sharply (and rather as I expected), "Let's
solve our own problems before we take on those of other people."

But I had not made my point after all for-would you believe
it-1here turned out to be no way in which I could convince her of
the inconsistency in her position.

But we have to take people as they are; complete with their
aversion to the rational; and face, in these last decades of the
twentieth century, the most crucial problem mankind has ever ha-
to deal with. It is the question of sheer survival; not for this
sect or that, this nation or that, this political or economic doctrine
or that-but, quite simply, for civilization generally.

And maybe even for mankind generally.

And maybe even for multicellular life generally.

The prime problem is that of increasing population, so-ethnc
I considered forcefully in the previous chapter, an? a~ taking up
even more forcefully in this final chapter. Even If, nght ow as
of this minute, the population of Earth levels off.. we still face
an overwhelming problem. The population of Earth IS already too
high for survival, for we grow in other ways than mere numbers.