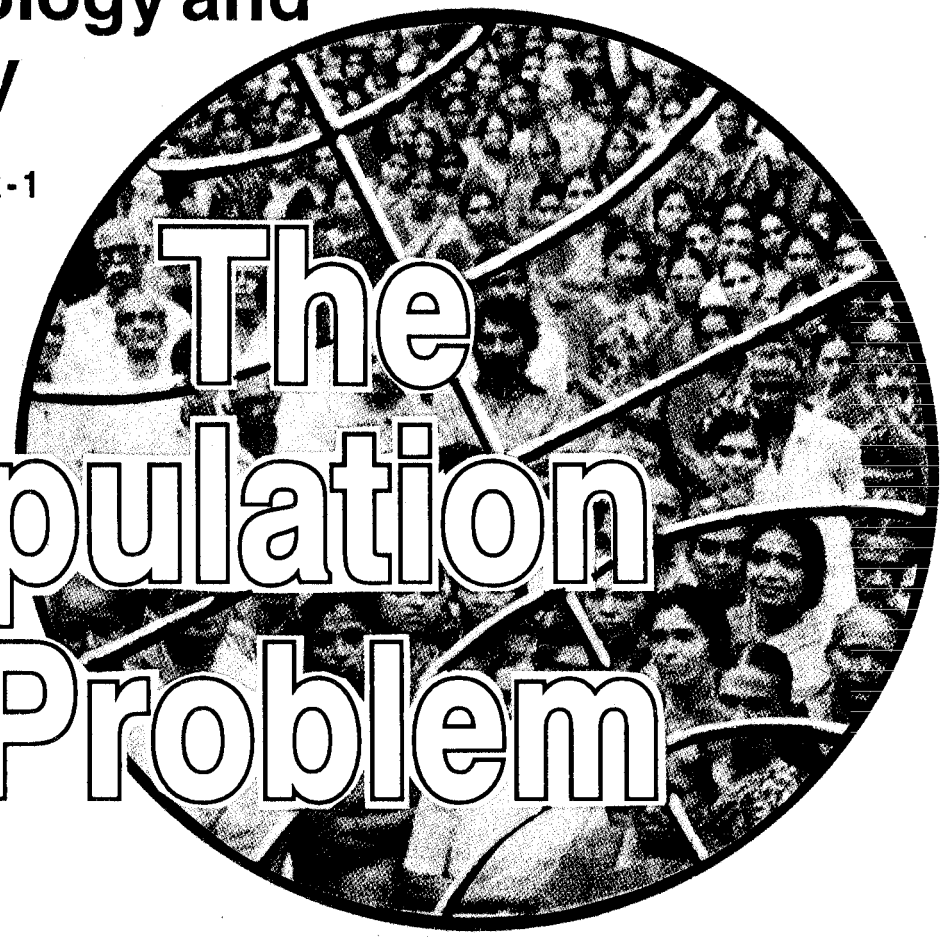
Activity Based Foundation course on Science, Technology and Society

Curriculum Book - 1



The Population Problem

Chitra Natarajan

Homi Bhabha Centre for Science Education
Tata Institute of Fundamental Research

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The sensitivity to current issues and concern about education of young people evinced by Mr. V.G. Kulkarni, Founder Director of HBCSE, guided the project from its inception. Several issues addressed in the programme had their origin in a book planned by Mr. V.G. Kulkarni, Dr. G.P. Phondke Dr. S. Pandya and the author. Discussions with Dr. Phondke and Mr. Kulkarni have enriched the content of the series. In fact, the idea that 'survival of humankind' is an important basis for discussing the issues, was suggested by Dr. Phondke.

HBCSE Director, Dr. Arvind Kumar's commitment to enrichment of students and his participation and support in drawing up the content and format of the programme, contributed immensely to the success of the project. The series of booklets, of which this is the first one, is a direct outcome of the programme. Dr.Arvind Kumar has been actively involved in planning the overall content of the booklets. His encouragement and gentle nudges have been useful in bringing them out over a reasonable time span.

Besides Dr. Arvind Kumar, Drs. Bakhtaver Mahajan, Sugra Chunawala, G.C. Pal and Ms.Sandhya Karande conducted several sessions. Some of them will be writing a few of the booklets. Drs. B.M.Udgaonkar and H.C.Pradhan encouraged the programme, read the manuscript and offered valuable suggestions.

The participants of the programme in Mumbai were students from arts, commerce and science faculties of two junior colleges in the vicinity of the Centre. They performed many of the activities included in the books and thus enriched this endeavour by their enthusiasm and feedback. Their quest for meaningful activities is the *raison d'etre* for this activity based curriculum.

Bringing out books of this kind involves a variety of tasks, like clarifying references, getting drafts printed, choosing appropriate illustrations, coverpage layout, photocopying, and so on. In referencing, wordprocessing, printing and illustrations, it is a pleasure to acknowledge Ms.Yogita Parab's help, which was often sought and willingly given. Her capacity to learn new computer software was a valuable asset. Drs. G. Nagarjuna and K. Subramaniam have been of immense help in providing the needed human interface in all our computer interactions. Everyone at the Centre contributed to providing a problem-free working atmosphere.

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The foundation curriculum

1.1 The need

The complex web of interactions between all spheres of human activity demand that prospective decision makers possess a repertoire of skills complemented by a reasonable capability to communicate their strengths, in oral and written form. Many of these skills are dependent on the domains of specialization: the study of biology may hone observational skills and the ability to classify and categorise; mathematics calls for logical skills, and the pursuit of sociological sciences calls for critical thinking and the ability to make complex linkages.

Both teachers and the taught readily acknowledge that science, technology and society are intimately linked. However, these linkages are complex. Hence, they require different methods to be adopted in classrooms to encourage the students to form such links. These pose problems for the teacher.

A factor that makes teaching issues at the interface of science, technology and society even more difficult is the proliferation of information. The information boom also comes in the wake of crumbling national barriers for trade and information exchange and a global notion of neighbourhoods. Societies and individuals are reacting more rapidly to global changes than they ever did before. Changing environmental perspectives in Europe have led to migration of polluting industries into the developing countries. Tension in the Middle East or West Asia becomes an immediate cause for concern in Kerala. War, destruction, concern, recovery, rebuilding, and war again - cycles that used to take hundreds of years in previous centuries, now have a periodicity

of less than ten years. Contemporary issues not only affect all citizens to some extent, but also call for a systems approach to its understanding and resolution, considering among other things, the technological, economic and socio-cultural linkages. This approach requires a certain attitude to problem solving.
Appropriate training can enable students to acquire problem solving abilities. However, increasing content specialization after grade ten, and lack of an integrated approach to learning before that, are hurdles to such a training. This situation can be partially remedied through intervention programmes, be they at the level of higher education, or during professional on-the-job training.

1.2 A programme for post-school students

Such a training formed the principal objective of the programme funded by the J.N.Tata Endowment Trust, and implemented by HBCSE over three years at Mumbai and also for two years at Solapur. Developing a sensitivity to, and an understanding of, the complex linkages between science, technology and society, was the basis for the programme that aimed at promoting 'good citizenship' qualities among post-school students. The other vital input was strengthening the comprehension and communication skills of the students.

1.3 The curriculum

1.3.1 Genesis

The success of the programme, measured in qualitative terms — heightened sensitivity of the participating students, and their sustained interest has inspired this Foundation Curriculum. The curriculum has been embodied in a series of books. The objectives of the curriculum preclude it from being a textbook. Instead, this curriculum outlines a series of activities that lead the participant from simple issues and ideas to complex ones, requiring the students to make linkages. The activities are also designed to develop the skills necessary for a practical understanding of issues at the interface of science, technology and society.
Most activities suggested in the books have been tried with post-school students during the programme. These could be used by any interested person

— a teacher or leader of a forum — to develop comprehension and communication skills among members of a group of young people. They will be working on a broad canvas of issues at the interface of science, technology and society. Outlined below are the objectives of the curriculum, guidelines for interaction, and the topics, chosen for convenience, under which various issues will be discussed.

1.3.2 Objectives

The objectives of the curriculum can be summarised as follows.

- Offer guidance to students in improving their English comprehension, communication and analytical skills, besides quantitative reasoning. English has been chosen in the light of its being the language of global information flow.

- Integrate their curricular knowledge with environmental and developmental issues of concern, thus giving a broad exposure to several disciplines.

1.3.3 Guidelines

Setting guidelines for interaction between the group of students and the teacher, will go a long way in achieving the objectives stated above. A possible set of guidelines could be the following.

a. Sessions should be conducted in a participatory and interactive mode.

b. Sessions should involve thinking across disciplines, stretching the ability of participants to think beyond the obvious connections.

c. Relevance of the issues to daily life should be stressed and participants should be guided in making decisions.

d. Weaknesses and lacunae should be assessed at intervals, through appropriate questionnaires.

e. Skills should be developed through suitably designed activities. These could include the following.

- writing persuasive essays, poems, letters to local newspapers
- writing and staging streetplays
- debates,
- analysis of tabulated information,
- comparison and quantification,
- drawing charts and graphs,
- designing games,
- conducting interviews and surveys, and
- visits to industries, research institutes.

1.3.4 Content

Activities designed to meet the objectives of skill development are grouped under issues of current concern. As already mentioned in section 1.1, the issues are all interlinked and need to be treated that way. For convenience of presentation, these are discussed under the following topics.

- Survival of Humankind: Curricular Philosophy, and The Population Problem
- Education
- Health — Diseases, Drugs, and New Challenges
- Resources: Land, Air, and Water
- Resources: Food
- Resources: Energy
- The Environment — Balance in Nature
- The Environment — Degradation, Science and Technology
- Information Revolution and the Media
- Social Conflicts, Gender Issues and World Peace

The present chapter, an introduction to the curriculum, is a part of each book, with a variation only in Section 1.4. It would be useful to revisit the discussion on *Survival of humankind* given in the book on "The Population Problem".

1.3.5 Target group

The ten activity books are designed to be adequate in content for a 2-year course in Science, Technology and Society at the Higher Secondary level. All the activities can be dealt with over a span of 200 contact hours. Some of the activities require the participants to collect data by library search or survey outside contact hours. However, many activities, mentioned in Section 1.4 of the respective books are essential for giving students a flavour of the issues. These may be covered over a span of 100 contact hours, about 10 hours per book. The large number of activities given in each book allow ample scope for a flexible and innovative approach to teaching the above listed topics.
The activities outlined in the books can, however, be used with any group of individuals with a minimum schooling of standard X (grade 10). It has been found to be harder to work with groups exceeding 30 members. However, this problem can be overcome by dividing the group into subgroups of smaller size. There must be a common language of communication within the group. Since it is most likely that the books will be used in a classroom situation (say, higher secondary class), the participants are referred to as *students* in all the books.

1.3.6 The group leader

The objectives will be patently met if the group consists of a leader or coordinator, who has more than a cursory interest in the developmental issues of concern today, and enjoys making linkages. The students should be guided not only in making the obvious links, but also to go beyond them.
A coordinator with a formal training in cross-disciplinary thinking has a clear advantage, but a person with an open mind to the ideas of others, and one who feels that students cannot be all wrong, would do just fine. It would be useful for the group leader to be proficient in English, so as to be able to read and comprehend the proliferating information and communicate this to the group. It is most likely that the leader will be the teacher, and hence *teacher* in the books will mean the leader or coordinator of the group.

The leader plays a special role in all the activities outlined. The cardinal principles that govern the interaction of the leader with the group include the following.

i. Understand and value individual and group perceptions.

ii. Encourage listening by setting an example.

iii. While moderating discussions, support the apparently indefensible viewpoint.

iv. Attempt to raise the discussion from the level of free-standing personal statements —'I feel', 'I think', etc., with no accompanying justification — to coherent and logical arguments, with quantification wherever possible.

v. Allow for changing and evolving views during discussions and show a willingness to learn from the students.

vi. Encourage following firm rules during a debate.

vii. Facilitate and liven up discussions by introducing a new angle whenever possible.

viii. Use the 'let us find out' mode as often as is appropriate.

The role of the leader is far from a passive one. Encouraging the diffident student, guiding the overly confident one, finding loop holes in the arguments of a member without lowering self-esteem and being in control of the situation in a class full of thinking individuals is a challenging task. Yet, if viewed as an opportunity to improve one's skills of critical thinking, at the same time creating a generation of thinking individuals, the joy of such interactions can be infectious.

1.3.7 What this is, and what it is not

As already explained in Section 1.3, these books are not substitutes for textbooks, nor are they comprehensive. They are meant to give students a feel for 'real world' problems, without introducing the intractable complexities all at once.

There are very few problems of concern today that have either globally applicable, or locally unique, answers. As in any reasonable developmental approach, the answers to many questions must be sought within a local framework of society, politics and economics. In fact, increasing students' sensitivity to local needs and problems and putting these in the context of global concerns, constraints and opportunities, with examples of solutions arrived at in different contexts, is a tacit aim of the Foundation Curriculum. Hence, it is an advantage for leaders and group members to have access to information, both local and global. The bibliography is indicative rather than exhaustive. Definitions and concepts can be sought and found in any relevant textbook available in a junior or senior college. Newspapers and locally available magazines could be additional and sometimes valuable sources of issues of debates. Many newsgroups and voluntary agencies provide information and backdated clippigs files free of cost or at a nominal charge. The group must, in the course of the interaction, generate and catalogue clippings files on issues of concern to the group.
The important, but rather difficult, questions of evaluation have not been addressed here. In this curriculum, more than in any other, evaluation of any form is a measure not only of participant's comprehension, but also of the effectiveness of the leader. Test questionnaires have been provided in most of the books as guidelines to assess effectiveness of interaction in the course and to help take corrective measures.

1.4 This book

This book is meant to be the first one in the series. The population of India, a sixth of the world population, is often perceived as a major hurdle to increasing the quality of life of the country's people. The response to increasing population varies from a Malthusian doomsday prediction to a utopian vision of an empowered billion people ruling the world. The activities, over 20 in number are meant to give students a foundation for critical thinking on this issue. Opportunities are provided to address questions like, "Is population a problem of numbers?" or "What factors effect changes in population growth rates?" The author herself takes the optimistic stand that if the problem is addressed properly, population can be perceived as human resource, whose quality is decided by awareness and skills.
All the activities, if attempted in full measure, could take about 20 contact

hours. However, Sections 3.4, 3.5, 3.8, 3.9, 3.10, 3.11, 3.13, 3.15, 3.17, 3.18 may be taken up for a shorter course. Section 3.19 may be taken up with any of the issues. It is a quantification activity that also addresses many linkages between issues. It would be especially suitable after a discussion on science and technology.

Chapter 2

Survival of humankind

Discussions of issues hinge on two important assumptions: it is important that human beings continue to live on earth for relatively long periods of time into the future, and the issue being discussed affects the survival of human beings. Hence, before beginning the actvities it is essential to understand the perceptions of the group about survival of human beings. In fact, a discussion on this topic sets the stage for all the participatory sessions and activities that follow. The issues that will form the backbone of the curriculum can be anticipated and elicited from the group through the preparatory discussions, followed by a debate.

2.1 Activity 1: Clarifying ideas and positions

A set of questions is formulated to get the group thinking about survival and what that means. For this activity, the group is divided into subgroups of about 4 to 8 members each. A handout containing the questions given below is given to each subgroup. They are asked to formulate answers to the questions within a stipulated time. The answers to some of the factual questions should be discussed with the group as a whole, and answers provided. Students must be encouraged to form coherent working groups, and arrive at consensus within subgroups.

2.1.1 Assessment

A questionnaire administered to every student before and after the discussion and debate will help gauge changes in attitudes and positions of the students with respect to the survival issue. A sample questionnaire is given in Appendix A. The questionnaire, which consists of both fixed response and free response questions can be suitably analysed.

2.1.2 Questions on survival of species

1. What do we mean by words like species and race?
2. What do we mean by 'survive'? Use of the word.
3. What are survival needs — of individual humans, of an animal, a plant?
4. What do we mean when we say 'survival of humankind'?
5. Do you think it is important for the human race to survive?
6. For how long should the human beings survive? Justify your stand, attempt to reason why you 'feel' that way.
7. Do you think it is important for living species other than human beings to survive? Give reasons for your answer.
8. List the main differences between humans and other living species. Did your reasons involve any of these differences?
9. Will any of the differences stated by your group affect the survival of the species? If yes, say how it will affect survival.
10. In the light of your answers to the above questions, do you think there are threats to survival of humankind?
11. List out all the issues that you 'feel' could threaten existence of human beings.
12. Do you think there are possibilities of avoiding or overcoming these threats? Whatever your answer, justify by giving reasons.
13. Go over your responses to this questionnaire carefully.

14. Based on your responses to the above questionnaire, what would be your response to the question, 'Is the survival of human beings on earth threatened or assured?'

2.1.3 Discussion of responses

In the above question set, three words need to be defined. Students should be encouraged to look into a Dictionary, and find their meanings. The leader should have referred to them before the session. If there are multiple definitions for a word, for example, *race*, it should be pointed out and correct usage outlined through examples. The following working definitions will help clarify the discussion.

Species is a technical term, used for a group of organisms generally resembling each other and capable of reproduction.

Race is a group of persons, animals, or plants sprung from a common stock. It could also mean a species or variety of plants, or animals persisting through several generations.

Survive means to be still alive, to be in existence after an event, period of time, or a change of circumstance. This word is used in the context of a person, thing, or custom being in existence even in a new state of things, that is, in changed conditions. 'Survival of the fittest' refers to the preservation of forms of life that have proved themselves best adapted to their environment.

A discussion of the survival of humankind, beginning with the expectations and aspirations of the present students will set the stage for interactions among them. This can be followed by a discussion of the following points,

- Survival of the present generation into the next,
- The period over which humankind is known to have survived over this planet,
- The period over which each group 'feels' humans ought to survive, and
- Why should *we* worry about survival?

This will lead, again, to the differences between humans and other species, already addressed in the question set above. Of all the differences that students may cite, the wisdom of human beings is the most important. It must be emphasized that the ability of human beings to 'learn' from the past, and 'predict' the future, however flawed it may be, and the potential for wisdom are important arguments for their survival over many generations. Having established that survival of humankind is important, the perspective about the period may vary among students. This may be decided by common consent of the group. The students are then ready for a debate on the threats and the assurances to survival of human beings.
Each subgroup is encouraged to vote 'yes' or 'no' in response to the last question. The leader actively encourages the polarization of the views in the group by arguing in favour of the response with fewer supporters.

2.2 Activity 2: Debate

During the ensuing debate, all threats to survival are clearly brought out (enunciated), such as,

- the population problem,
- ethnic strifes, racialism, conflicts and wars,
- environmental degradation and ecological imbalance,
- food security for all,
- misuse of technology,
- depletion of (non-renewable) resources and rampant consumerism,
- new health hazards and abuse of drugs,
- erosion of social institutions, changing values,
- literacy rates, and the education system, and
- evolving gender roles.

The assurances, on the other hand are exemplified, by the use of science and technology in the following areas,

- methods to alleviate pain and health problems,
- increased food production,
- biotechnology and genetic engineering,
- space exploration,
- mass media and communication,
- transportation,
- processing, storage and preservation of food and biological products,
- increased energy production,
- genetic resource consolidation, and preservation,
- utilizing renewable resources and conservation of non- renewables,
- water treatment and closed cycle use,
- facilitating an overall improvement in quality of life.

The discussion should reveal contradictory roles of many issues, which appear as both threats and assurances. It should also raise questions about standard of living, quality of life and the difference between the two. These need not be answered at this juncture. The discussion should motivate students to anticipate and actively participate in activities given under the appropriate titles.
Having thus encouraged the students with suitable hints to list out all the threats and assurances, the co-ordinator summarises the discussion. The summary should include the following:

- It is not a trivial matter to take sides on issues that concern the survival of humankind.
- It is necessary to study each of the issues in the light of all available information, comprehend the information, analyse it and then take informed decisions, conveying them through convincing arguments to those holding opposing views.

- According to available scientific information, humans alone, of all living beings, have been endowed with the potential for developing their analytical and quantitative reasoning skills, and hence the onus of using these skills 'wisely' for the survival of the race also rests solely on them.
- The lofty ideals set up above are sobered by the fact that humans have shown themselves prone to kill others of their own species in large numbers in wars and for territorial expansions.

The debate will thus lead to the forthcoming discussions and activities. It is not absolutely essential that the issues be taken up for discussion in any particular order. However, the population problem usually finds mention in most debates. Hence this seems like a good place to begin the next set of activities on *The population problem.*

Chapter 3

The population problem

3.1 Objectives

Activities in this section are designed to help students understand a few important ideas and to put the problem of human population in a historical perspective.
The species *Homo sapiens* (biological term for human beings) has been living on this planet for over 300,000 years. For 99 percent of this time span, most humans have lived either as hunter-gatherers, or in small communities of farmers. However, there have been tremendous changes. Some of these changes have occurred very fast — in less than one human life-time. It is easier to study the growth of human populations in the past than to make predictions about the future scenario. Yet, one could attempt to make predictions about future populations after studying the statistical behaviour of populations in the past and present. **Demography** is the study that deals with the statistical aspects of human populations — with reference to some of the features given below.

- Population size,
- Population density,
- Number of births and deaths,
- Population structure and composition, for instance,
  - number of males and females alive at a given time in different age groups (age-sex pyramid),

  - number of infants born in a given year,
  - fraction of population in different socio-economic strata at a given time,
  - fraction of the population above the school-going age who are literate at a given time (literacy rate),
  - number of people within the employable age who are employed at a given time,

- Spatial distribution of population, eg.
  - fraction of a country's population living in urban areas,
  - fraction of the world population in developing countries,

At least a cursory understanding of some of the above parameters is essential before their role in the population problem can be discussed. In addition, after carrying out the activities listed below, students should be able to locate information and find inherent patterns and trends in historical and geographical changes in population. They will be exposed to both local and global population numbers, and will be able to estimate their growth. The activities encourage students to know about local population through examples cited from India, its states and cities, and its neighbours. To understand the local population in a global perspective, data from other regions of the world are discussed.
Activities also address salient characteristics of the population of India, like,

- crude death rates (CDR),
- crude birth rates (CBR),
- population growth rate,
- infant mortality rate (IMR), and
- fertility rates.

Several activities are designed to help develop students' specific skills. The following are some of the skills sought to be developed.

- Ability to deal with the large numbers involved when considering populations,

- Practical application of absolute and relative values,
- Ability to deal with ratios, proportions and rates,
- Estimation of population growth rates by quantitative reasoning: annual and decadal rates, and percentage growth.

It is essential for the student to go beyond the mere definition of the many new terms involved in the study of the population problem. The activities are designed to help this process.
It is also important to address the question of whether population is "the" problem, the root of all problems, or one of the many linked problems. Students should be encouraged to respond creatively with solutions to the population problem, including viewing population as a useful resource.

3.2 Assessment: population quiz

A quiz administered before the start of the activities will help the teacher know students' ideas about population. A sample quiz on population is given in Appendix B. Alternatively a suitable quiz may be devised by the teacher. The quiz also helps the teacher focus on topics less understood by students, and which need to be supplemented with facts, exercises and additional activities. For instance, when dealing with large numbers, students are often unclear about conversions between lakhs, crores, millions, and billions — Indian and International place value systems. Students may also need additional exercises in pattern recognition in tables consisting of large numbers. Activities that follow address a few of these areas.

3.3 Your observations of population growth

1. Name the place where you were born, the place where you have stayed for most part of your life, and the place you visit most often during vacations. These places may be the same for some of you and different for others.
2. Choose the place you have known over the maximum period of time and list all the changes in the place:
    - number of houses in the neighbourhood,

- the approach roads,
- new streets or colonies,
- wild growth which has now been replaced by human habitation, and
- any other such notable changes.

3. Ask your parents and grandparents about the places where they grew up — about how it was during their childhood and now.

4. From the above comparisons, draw your conclusions about population growth and accompanying changes, in your time, in your parents' times and in your grandparents' times.

3.4 Pictographs

1. The population size in millions (M) for the years 1950 (left) and 1990 (right) are given for the following regions in Figure 3.1,

   - India
   - Developed countries
   - Developing countries

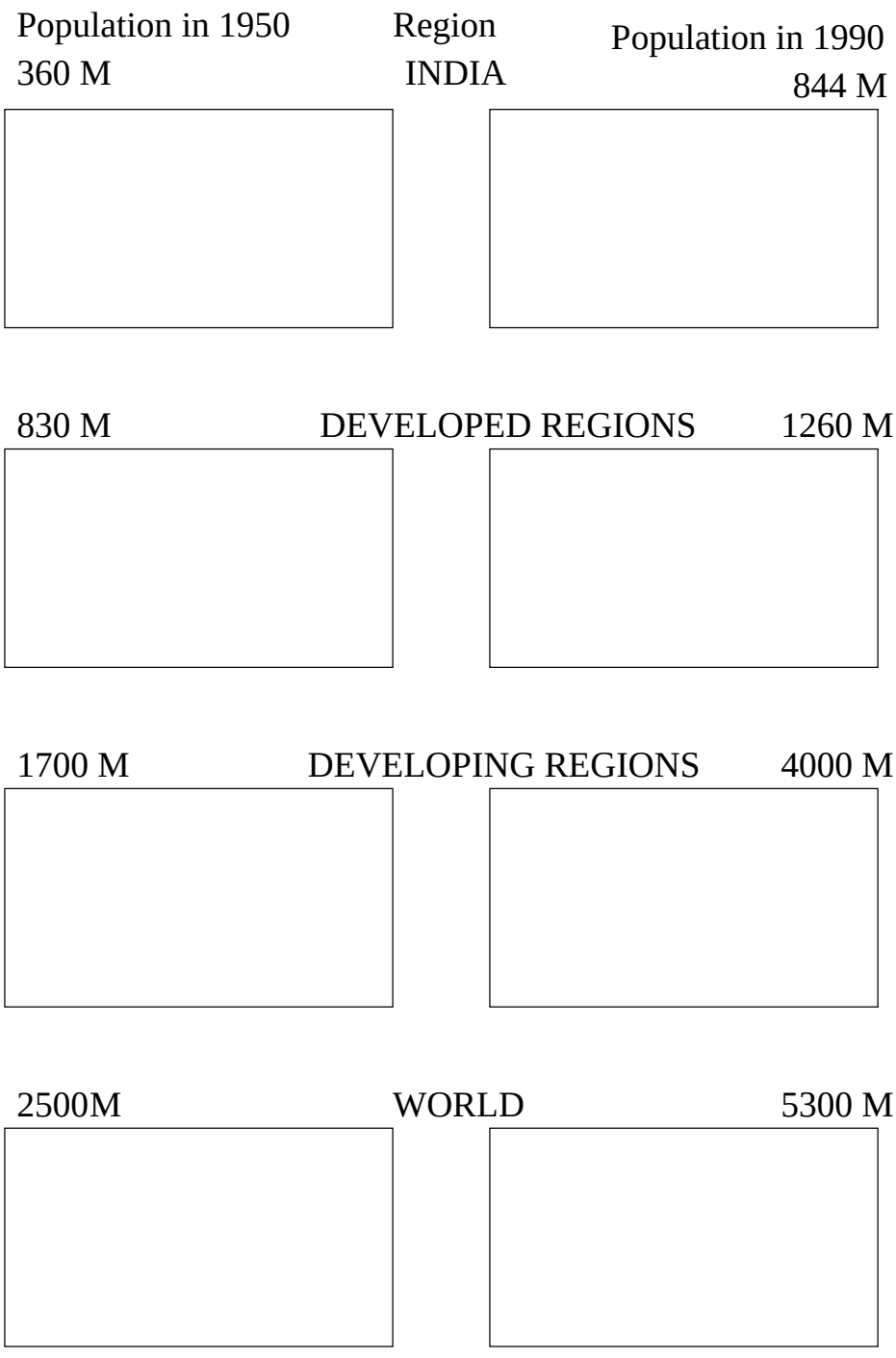
   Fill the rectangular boxes in the figure with suitable symbols. The pattern inside the boxes must be related in some way to the population numbers, that is, they must show the same pattern as being big or small with respect to one another. You would then have creatively told the story of population numbers in different regions at different times through your picture. Your representation is called a pictograph.

2. Discuss the picture you have drawn. What do you understand from the data about relations between the population in different regions?

3. Draw a bar graph to illustrate the same ideas. Choose suitable scales and label the axes and the bars (that is, give 'titles' and 'legends').

4. Carry out a similar exercise for the states of India. Select a few states you may be interested to know about, find out their population, say in 1950 and in 1990, and draw pictographs and bar graphs.

Figure 3.1: Pictograph



3.5 Population growth

This activity will familiarise students with how population changes over time. Considering the simple case of changes in regional populations caused by births and deaths only, several activities can be devised to clarify the process. The game must facilitate dealing with relationship of birth and death rates to absolute population growth and growth rate. One such activity is indicated below.

3.5.1 A game

You need 200 stones (or any other object) of a size that can be easily handled, a stop clock, two teams of players, and a referee. A watch with the seconds hand, or even a large container with water dripping into a cylindrical jar can serve as a time- keeper.
Divide the group of students into two teams and name them *Creators* and *Balancers*. Make one student the referee. Place 50 stones on the table in clusters of 10. Read the rules given below aloud in the class before start of the game. Follow the rules to play the game.

Rules

1. Referee starts the stop clock

2. After 30 seconds, *Creators* add one stone for every complete cluster of 10 stones — 5 stones for 5 clusters. *Balancers* take away one stone for every two complete clusters — two stones removed for 5 clusters.

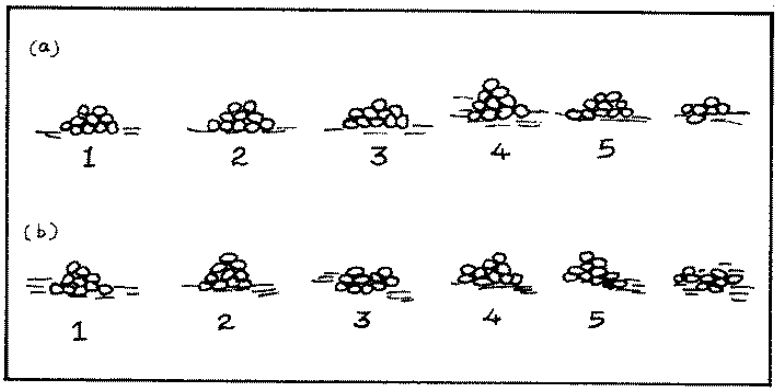
3. Referee rearranges the stones to have complete clusters of 10 stones and an 'extra' incomplete cluster. Referee also maintains a record of the number of complete clusters and number of 'extra' stones.

4. The above sequence of steps is repeated at the end of every 30 seconds. Figure 3.2 shows how the clusters will appear at the end of 1 minute (a) and 1 minute 30 seconds (b).

5. When the extras add up to 10 stones, a new complete cluster is formed.

6. The sequence of steps can be repeated for any predetermined time.

Figure 3.2: Clusters of stones at the end of (a) 1 min. and (b) 1.5 min.



3.5.2 Analysis of the game

1. After playing the game for 12 minutes, how many stones are there on the table? Consider each 30 second interval as one year, and note the increase in number of stones per 'year' (**absolute growth**) and express it as a percentage of the original number of stones (**percentage growth rate**). You will encounter these ideas again in Section 3.6.

2. Start again from where you left off (the number of clusters and 'extras' at the end of 12 minutes) and play the game for 12 more minutes. Calculate the absolute growth and percentage growth rate, as before. Comment on your answer.

3. Tabulate the number of 30 second intervals (each represents a year in this game) taken to get 1 **additional complete cluster** (that is a total of 6 clusters), 2 **additional complete clusters** (a total of 7 clusters), and so on. Plot "additional clusters" as a function of "number of years" taken to make them. Draw a smooth curve passing through most points? Comment on your graph. Is it a straight line? Justify.

4. The group is split into several teams, each consisting of *Creators*, *Balancers* and a referee, and about 200 stones. All the teams play the game simultaneously. For convenience there can be one person in the whole group with the stop clock, announcing the end of 30-second time intervals. Each team plays a variation of the game, that is, each team uses a different rate (rule) for adding and removing the stones. To mimic reality in most cases, addition rate must be greater than the removal rate.

   Rate of addition of stones by *Creators* is like the **Birth Rate** and the rate of removal of stones by the *Balancers* is like the **Death Rate**. Note the birth rates and death rates used by the different teams. In each case, compute the birth and death rates. This is called the **rate of natural increase**.

5. How long does it take in each case for the 'population' of stones to double? Find the relation between growth rate and doubling time (time taken to double). You will encounter this again in Section 3.8.

3.6 World population growth

This activity is intended to build upon an important skill introduced in Section 3.5.2: estimating growth rates. It will also introduce the following ideas and skills.

- Familiarity with data comprising large numbers (see Table 3.3)
- Reduction of data comprising large numbers to smaller, manageable numbers
- Representing data as graphs and using graphs to estimate trends
- Finding a pattern in a given data of large numbers
- Observation of quantitative relations within the data

3.6.1 Population trends

Scientists often study past population trends in order to make projections about future global population. Historians have estimated that global population in 1700 AD was about 700 million people. Since there were no world

Table 3.1: Global population from 1700.

Year	**Global Population (millions)**
1700	679
1750	769
1800	957
1850	1260
1900	1650
1950	2515
1985	4853
1991	5300

census reports then, these figures are largely based on observations and reports from studies of agriculture and commerce. We also know that the world population in 1991 was approximately 5.3 billion.

1. Using the blank graph provided in Figure 3.3, plot the first value (700 million) and the final value (5.3 billion).

2. Draw a trend line for the period by connecting those estimates of global population. Label this as 'Population Trend Line 1'. What are some of the intermediate populations between 1700 and 1991, say for the years 1800 and 1900?

3. The graph you drew above required you to interpolate (estimate the values for years between 1700 and 1991). You now find that additional information is available in the form of Table 3.1. Study the data in the table. Do you see a pattern in changes for each time period? Make a prediction about the trend line and how it will appear using the additional data.

4. What is the time span between each of the dates for the population information in the table? How will you adjust for different time spans on the graph?

5. Plot the data given in Table 3.1 and draw a new trend line.

6. Compare the first trend line with the second one. How is it diferent?

Figure 3.3: Global population 1700 — 2050, plot of trends

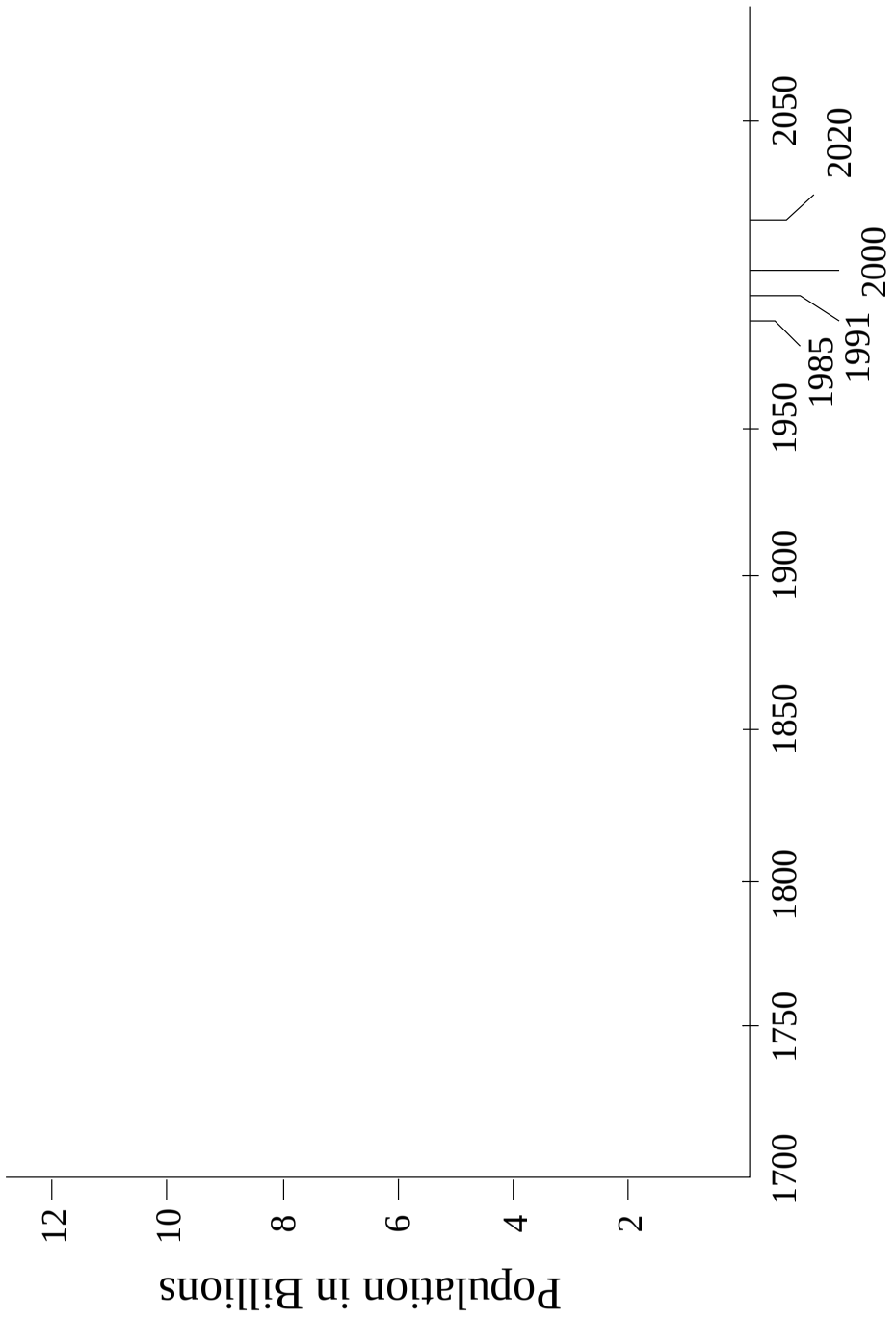


Table 3.2: Example of population growth

	Population in millions	
Year	India	U.S.A.
1980	694	226
1950	360	152
Increase	334	74

7. Why do you think the trend lines on the graph are different?

8. In a paragraph, describe how the global population has changed according to the graph you completed.

9. The population change you have researched so far required information about past global population trends. Is it possible to predict global population in 2020 AD? Is it acceptable in a scientific study to extend the trend line to the year 2020 AD? If you maintain the slope of the curve to about the same, what does it tell about future population change?

10. After extending the trend line on the graph, what is the predicted world population in 2020?

11. Why can it not be assumed with absolute certainty that the population will be at the predicted level in 2020 AD?

12. After making your prediction from the graph, you read and find that the population prediction by the United Nations for the year 2020 was 8,061 million. How does the UN prediction compare with your prediction? Account for the difference.

3.6.2 Rates of growth: an example

An example is given here to illustrate the estimation of population growth rate, which is generally expressed as a percentage of the initial population. Consider the population of India and United States of America (U.S.A.) in the years 1950 and 1980 (given in Table 3.2).
For India, average annual rate of growth from 1950 to 1980 was approximately,

Table 3.3: Population of India from 1881 to 1991

Year	**Population**		**Growth Rate %**	
	Actual	**To nearest million**	**Annual**	**Decadal**
1881	— —	— —	0.09	
1891	— —	— —	0.94	
1901	238,396,327		0.10	
1911	252,093,390		0.56	
1921	251,321,213		-0.03	
1931	278,977,238		1.04	
1941	318,660,580		1.33	
1951	361,088,090		1.25	
1961	439,234,771		1.96	
1971	548,159,652		2.20	
1981	683,329,097		2.22	
1991	843,930,861		2.11	

$$\frac{334 \times 10^6}{360 \times 10^6 \times 30} \times 100 = 3.1\%$$

For U.S.A. in the same period, the annual growth rate calculates to 1.6%. These values are also known as average annual percentage growth rates. By convention, growth rates are expressed in percentages, which may be annual (per year) or decadal (for 10 years).

3.6.3 Table analysis

Table 3.3 gives the population of India from 1881 to 1991 AD. Refer to the table and answer the questions given below.

1. Observe the first and second columns. What varies with what? Which are the independent and dependent variables? Has the population been always increasing?

2. Fill the third column. (Use the second column).

3. Plot a graph of population as a function of time. Describe the nature of the graph in your own words. Use the following checklist for a good plot:

   - Choose suitable axes for the plot
   - Name the axes — axes titles
   - Use suitable scale for each axis
   - Mark the scales

4. Describe the information in the fourth column (annual growth rate %) in your own words. How was it arrived at? Calculate the values in this column using the data in the first and second columns?

5. Calculate the percentage decadal growth rate, that is, the rate of increase of population over 10 year spans (a decade) expressed in percentages, and fill the last column. Compare your values for decadal growth rate with the annual growth rate of the corresponding years. What can you say?

6. Plot the annual and decadal growth rates as a function of time.

7. Has the population change been smooth throughout the period from 1881 to 1991? Explain how you arrived at these conclusions.

8. What is meant by the negative growth rate in 1921? What may have caused this?

9. Discuss the increase or decrease in population and any spurts (change in growth rates) in terms of the historical circumstances that may have caused it. First make a guess about what those circumstances or events could have been. Then, find out from a source book on world history what they actually were.

10. What does this table 'tell' you? Write a page on the population story revealed by the table.

Table 3.4: Estimate of India's population at constant rate of increase.

Year	**Population Calculation**	**Population in Millions**
1991		848
1993		888
1994	$8.88 \times 2 = 17.76$	$P = 17.76 + 888 = 906$
1995	$9.06 \times 2 = 18.12$	$P = 18.12 + 906 = 924$
1996		
1997		
1998		
1999		
2000		
2001		

3.7 Population estimates

This activity is intended to help students estimate future populations at given growth rates. This will also enable them to appreciate the exponential growth of population.

1. In Table 3.4, the population of India for the years 1991 and 1993 are given, and sample calculations are shown to estimate the population for later years at an annual increase of 2%. Fill the remaining rows in the table. Calculate the decadal growth rate. Is it different from 10 times the annual growth rate? Explain.

2. In 1991, the developing countries, representing 70% of the world population of 5.3 Billion, grew at an average annual rate of 2%. For the rest of the world, the average annual rate was 1.5%. Estimate the world population in 1992.

3. Assume that the average annual percentage growth rate of more developed countries is 1.5%, while that of developing countries is 2% as in the activity above. Using the population data given in Table 3.1, calculate the population of developed and developing countries in the year 2000 AD. (We assume here for convenience of calculation that these countries stay in the same category through this period. This may not reflect the actual case.)

4. Obtain the data for the present population and estimated average annual percentage growth rate. Estimate India's population after a year.

5. Obtain the data for average annual growth rate of world population at the beginning of the current year. If all the countries maintained their present growth rates, what will the world population be after 5 years? Be sure to calculate the total population of the world at the end of each year before finding the actual increase in population in the subsequent year.

3.8 Doubling time

The activity in Section 3.5.1 showed that time taken to double is related to growth rate. In the activity below you will note that growth rate and doubling time of the population of the world have both varied over the years. It is important to understand it in a historical perspective.
Table 3.5 gives the population of the world since 10,000 BC (the values before 1900 AD are clever estimates), its average annual increase and the time taken to reach that value from half the value (doubling time). Study the table and carry out the activities suggested below.

1. **(a)** Annual percentage increase = $y\%$ is calculated as follows:

$$Pop_{(now)} = Pop_{(then)} \times (1 + (y/100))^{(Present\ Year - Past\ Year)}$$

(b) Years to double (T_d) is given by,

$$T_d = \frac{0.69}{(y/100)} = \frac{69}{y} \approx \frac{70}{y}$$

Calculate doubling times using this formula. How close are your calculated values with those given in the last column?

2. Choose appropriate axes and scales and plot graphs to discuss the following:

Table 3.5: Population of the world, its increase and doubling time.

Year	**Population in Millions**	**Annual % increase (a)**	**Years to double (b)**
10000 BC	5	$< .05$	–
5000 BC	13	$< .05$	–
0	200	$< .05$	–
1300 AD	400	$< .05$	–
1650	500	0.1	1000
1700	600	0.4	170
1750	700	0.3	230
1800	900	0.5	140
1850	1200	0.6	120
1900	1600	0.6	120
1950	2400	0.8	90
1970	3600	2.0	34
1975	4033	2.3	33
1980	4415	1.8	38
1985	4830	1.8	38
1990	5275	1.8	38
1995*	5700	1.7	40
2000*	6200	1.6	43

Note: * These values are projections based on 1991 trends (World Development Report 1991, 1992).

(i) Describe in mathematical terms (linear, geometric proportions, exponential ..) the rate of change in total world population over the years.

(ii) How has the population growth rate varied over the years? What reasons would you give for such variations?

(iii) How has the doubling time varied over the years?

(iv) In the light of the plots, write down your ideas about the present population, and your guess about future trends in populations and population growth.

(v) What, according to you, should be the annual growth rate of world human population? Justify your answer. **You should come back**

to this issue at the end of the course —after all the activities in the course have been attempted.

3. If a population is found to have an annual growth rate of 2.0%, how many years will it take to double? How long will it take to increase one thousand (1000) fold? In each case, make 'back–of–the–envelope' calculations to give your estimates.

3.8.1 CBR and CDR — birth and death rates

Crude Birth Rate (**CBR**) of a region in a particular year is the number of **births** in the year for every 1000 people in that region. Similarly, **Crude Death Rate** (**CDR**) of the region is the number of **deaths** in that year for every 1000 people in that region.
Let us see how these two basic measures of population growth and important characteristics of a population are computed.
In CBR and CDR, 'crude' refers to the fact that the rate is computed using all persons. That is, it is not adjusted for variables such as age or sex.
For any geographical area or ethnic group, crude birth rate or CBR is computed as follows.

$$CBR\ in\ year\ X = \frac{No.\ of\ live\ children\ born\ in\ year\ X}{Midyear\ population\ in\ year\ X} \times 1000$$

The midyear population is chosen as the base because it is most likely to be the closest to the average population of the year.
Similarly, crude death rate or CDR is computed as follows.

$$CDR\ in\ year\ X = \frac{No.\ of\ death\ in\ year\ X}{Midyear\ population\ in\ year\ X} \times 1000$$

The difference between these two rates is called the **rate of natural increase**. That is,
Rate of natural increase in year $X = CBR - CDR$
This equals the change in population per 1000 people.

3.8.2 Patterns in CBR, CDR and growth rates

1. In India, during 1985, there were 30 births for every 1000 people, and 12 out of every 1000 people died that year. Compute the rate of natural

Table 3.6: CBR and CDR for a few countries (to be filled).

Country	Data for 1981		Data for 1991		Annual growth rates	
	CBR	CDR	CBR	CDR	for 1981	for 1991
USA						
UK						
Sweden						
Germany						
France						
Japan						
Bangladesh						
India						
China						
Mexico						
Brazil						
Tanzania						

increase during 1985. What was the annual growth rate for India in 1985?

2. Find out the CBR and CDR of the countries given in Table 3.6 for 1981 and 1991, and fill the table. World Development Report [21] or a Gazetteer [43] is a good place to try.

3. Discuss the systematic differences between the values of CBR and CDR of the different countries.

4. Group these countries according to the values of CBR and CDR — low, medium and high values.

5. Fill the last two columns with annual growth rates of the countries for 1981 and 1991. Comment on the values for the three groups of countries.

3.9 Age-sex composition

At this point, we should ask whether the actual population depends simply on the number of deaths in a year, irrespective of who dies. Deaths among

infants, old persons and women of child-bearing age will all affect population growth in different ways. Thus, the dependence of actual population growth on the number of deaths in a year is not a simple one. The following example will illustrate this point.

Imagine a hamlet (small village) with a population consisting of 100 people: 3 infants, 7 children, 50 adults under 65 years of age and 40 people at least 65 years old. Suppose that during an entire year no one moved in or out of that population. Seven of the women under 65 years had babies in that year, and 2 of the people over 65 years died.

At the end of the year the population would be $100+7-2=105$. This would amount to an annual growth rate of 5% (calculate this for yourself).

What would have been the annual growth rate if there had been one person less in the population to begin with? That is, initially there were 99 people, say one infant less (only 2 infants). There would have been 7 births and 2 deaths, resulting in a population of 104 at the end of the year, giving an annual growth rate of,

$$\frac{104-99}{99}\times 100=\frac{500}{99}=5.05\%$$

What would have been the growth rate if the population was missing one of the women who gave birth to a child that year? The population at the end of the year would have been only 103 (one birth less — $99+6-2$) giving an annual growth rate of,

$$\frac{103-99}{99}\times 100=\frac{400}{99}=4.04\%$$

On the other hand, if the initial population had missed one of the elderly people who died that year, the population at the end would have been (one death less) $99+7-1=105$ at the end of the year, with a growth rate of,

$$\frac{105-99}{99}\times 100=\frac{600}{99}=6.06\%$$

Thus, unlike the growth of money in the bank, or stones in the game in Section 3.5.1, the population growth in a year not only depends on the number of people at the beginning of the year, but also on the age groups and sex of the people. That is, the age and sex composition of the population plays a crucial role in determining its growth rate. You will discuss the effect of these factors in the age-sex pyramid activity in Section 3.11.

Activity

1. Create a scenario of initial population as given in the above example. Choose a suitable distribution of population by age and sex at the beginning of a year.

2. Choose a certain number of births and deaths, specifying who dies, as in the example above. Compute the population at the end of the year, and the growth rate in that year.

3. Consider one less person than your initial population. In each of the following three cases, compute the population at the end of the year and the growth rate in that year. Comment on your answer.

   - the missing person is a male adult,
   - the missing person is a person who died that year,
   - the missing person is a woman who gave birth to an infant that year.

3.10 Infant mortality and fertility rates

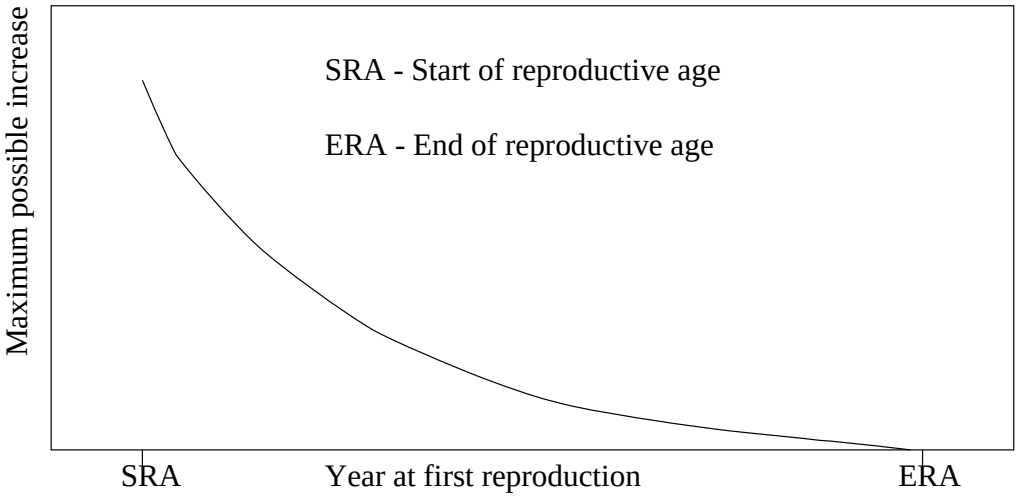
In the previous section it was shown that besides death and birth rates, the age and sex composition of the deaths also mattered in determining population growth. In this section you will see that fertility of women and infant mortality also play a major role in determining population growth.
Consider the following human populations in two regions:

1. All women bear 3 children, one each year, starting at an age of 18 years.

2. All women bear five children, one each year, but starting at the age of 30 years.

Which population do you think will grow at a faster rate? If you guessed the first one, you are right. An important factor affecting population increase is the age of a woman at which her first offspring is born, averaged over the population. This characteristic for a population is termed **'age at first reproduction'**. Figure 3.4 illustrates the effect of age at first reproduction on the innate capacity for population increase. The innate capacity for population increase is the maximum possible population increase. The picture

Figure 3.4: Effect of age at first reproduction on population increase.



suggests that as the age at first reproduction reduces, the maximum possible population will increase. Can you now link the government campaign to increase the marriageable age of men and women to this parameter?
Thus, of the many factors that limit population growth, the following have a direct influence:

- The age of a woman at which her first offspring is born, averaged over the population or 'age at first reproduction'.
- 'Total fertility rate' (TFR), the total number of children a woman in the population can be expected to bear during the course of her life, if birth rates remained constant for at least one generation. This is a prediction and gives an average value.
- The number of children who survive infancy, considered up to age of 5 years. This is related to another factor called 'infant mortality rate' (IMR).

The following activities will clarify some of these connections further.

3.10.1 World fertility trends

In this section you will link the effect of trends in fertility rates to annual population increase. [60]

Figure 3.5: World fertility trends 1950 - 2020 (1950 - 1990 estimates; 1990 - 2020 projections).

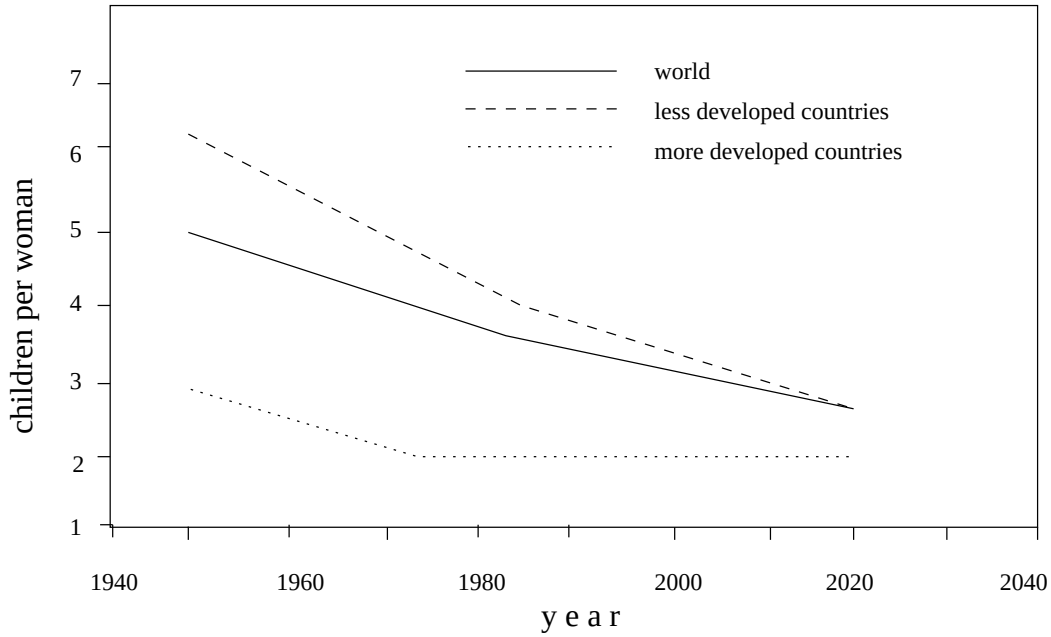
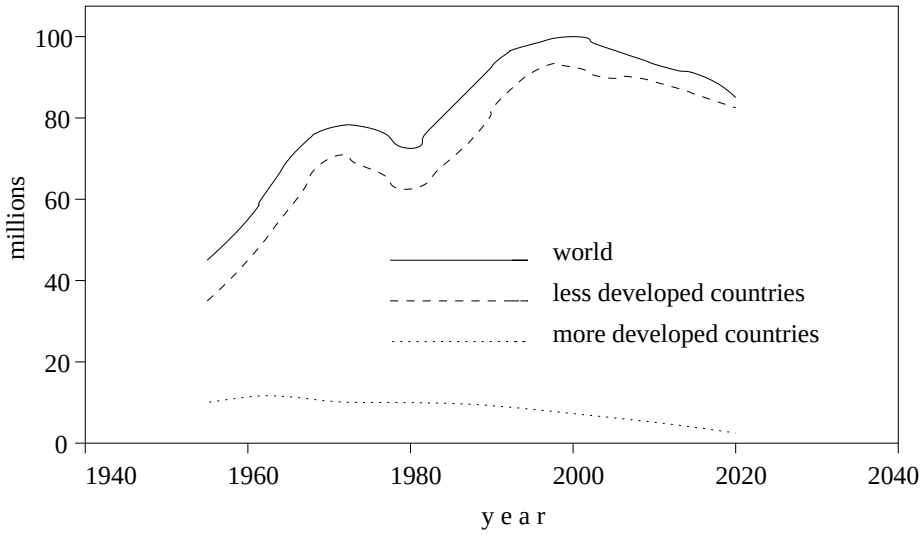


Figure 3.5 [60] shows how the average number of children predicted for each woman may be expected to change with time. This represents world fertility trends. The trend lines are shown for the world, for less developed regions and more developed regions.
Figure 3.6 [60] shows the average annual increase in global population (in millions) for the world, for less developed regions and more developed regions. Study the figures and answer the questions below.

1. Compare the trend lines on both graphs.
2. In which year will the annual average change in global population begin to decline?
3. How many years does it take for a decline in the fertility rate to begin having an effect on annual population increase?
4. Why does this time lag occur?
5. What are the implications of this time lag for global change?

Figure 3.6: Annual increase in population (1950 - 1990 estimates; 1990 - 2020 projections).



3.10.2 Education, infant mortality and fertility

Scientists are never absolutely certain that their predictions about population trends will be correct. Many things can happen to alter the trends. In this section you will discuss some of those.
Study Figure 3.7 and Figure 3.8 and discuss the questions raised below.

1. According to Figure 3.7 and Figure 3.8 (adapted from *Global Change* [60]), what role should education play in global change?

2. Would this be true for men also? Why?

3. What regions of the world should receive greater attention for improvements in basic education?

4. How might a greater educational focus in the regions you chose above alter the population predictions for 2020?

Besides the important influence of education, many things can happen to alter population trends. Improvements in health and sanitation may extend life expectancies and reduce infant mortality rates. Improved diet and greater

Figure 3.7: Children of educated women live longer

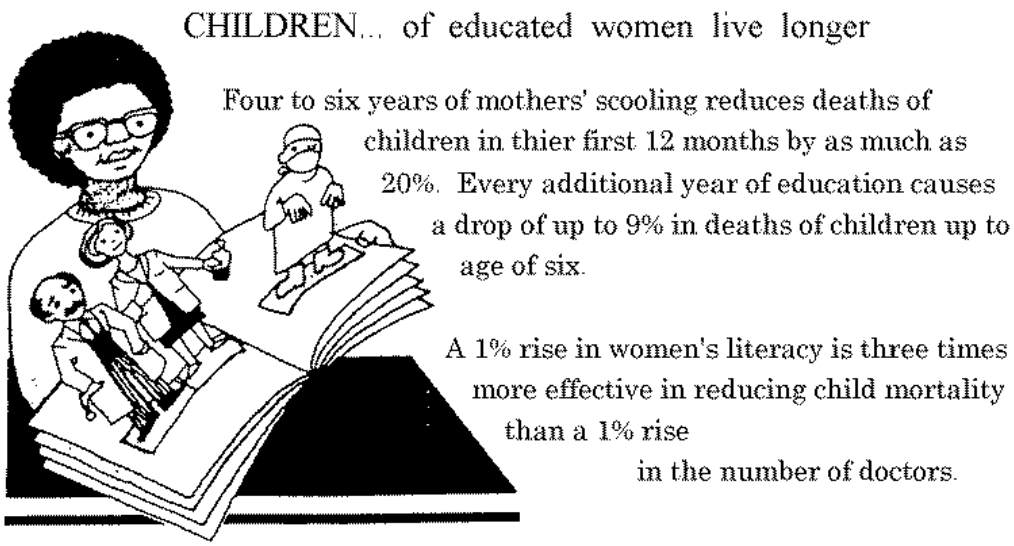


Figure 3.8: Educated women have fewer children

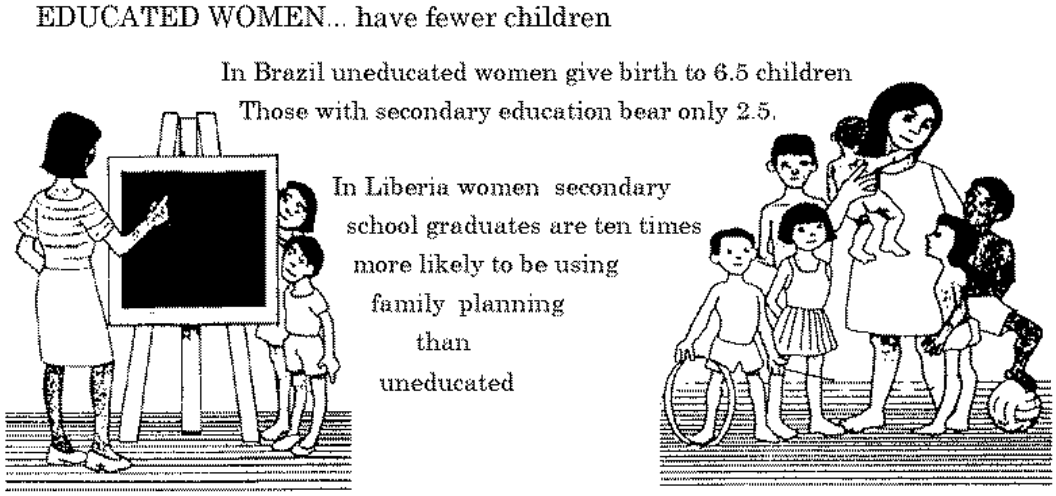


Table 3.7: Data format for age-sex pyramid

Age (in years)	**Males (No.)**	**Females (No.)**	**Earning**	**Literate**
0 – 4				—
5 – 9				
10 – 14				
15 – 19				
20 – 24				
25 – 29				
30 – 34				
35 – 39				
40 – 44				
45 – 49				
50 – 54				
55 – 59				
60 – 64				
65 – 69				
≥ 70				
TOTAL				

economic security may affect population trends. On the other hand, catastrophes such as droughts, floods and warfare may also alter population trends. These issues will be discussed in other books in the series.

3.11 Age-sex pyramid

In this section, you will plan a survey and collect data. You will then classify, tabulate and depict the data graphically as the age- sex pyramid. Discussion will bring out the information content in such a picture. It should also caution you against generalization based on limited data.
Each student should survey about 20 independent households (preferably not directly related to one another), and collect data about the number of members in the household, their sex and age. You could also gather information about the number of earning members, their age, and how many above the age of 7 years go to school, or are literate. The data of the whole class is then tabulated as shown in Table 3.7.

1. On a graph sheet, use the y-axis for representing **age**, negative x-axis for **number of males** and positive x-axis for **number of females**. Represent the above data in the form of a histogram, with bars on either side of the y-axis. This is called the **age-sex pyramid**.

2. Describe the shape of the histogram obtained. What can you say from the histogram about the distribution of males and females in each age group?

3. Discuss the significance of different shapes:

    - a graph with a broad base, and a tapering top — like an old-fashioned loudspeaker placed face down
    - a graph in the shape of a soda bottle, and
    - any other conical shape you can think of.

4. The age-sex pyramids of five countries are given in Figures 3.9 and 3.10. What can you say about the age and sex distribution of the populations in these countries? Attempt to make up a story, calling upon your knowledge of history, to explain the shape of the pyramids.

5. Find out the age-sex pyramids for various countries at different times (e.g. USA, UK, Sweden, Germany, France, Japan, Bangladesh, India, China, Mexico, Brazil, and a few sub-Saharan countries). Describe the difference between their shapes.

    - What would a broad base, tapering quickly to a narrow top indicate about the country's population?
    - What would a narrow base, a broader middle, and a slightly narrower top rising high indicate?
    - Relate the shapes with the CBR and CDR that you are now familiar with.

6. Predict the shape of the future population of India 25 years and 50 years from now.

Figure 3.9: Age-sex pyramids. (a) USA in 1970, (b) Sweden in 1970, (c) Mexico in 1970

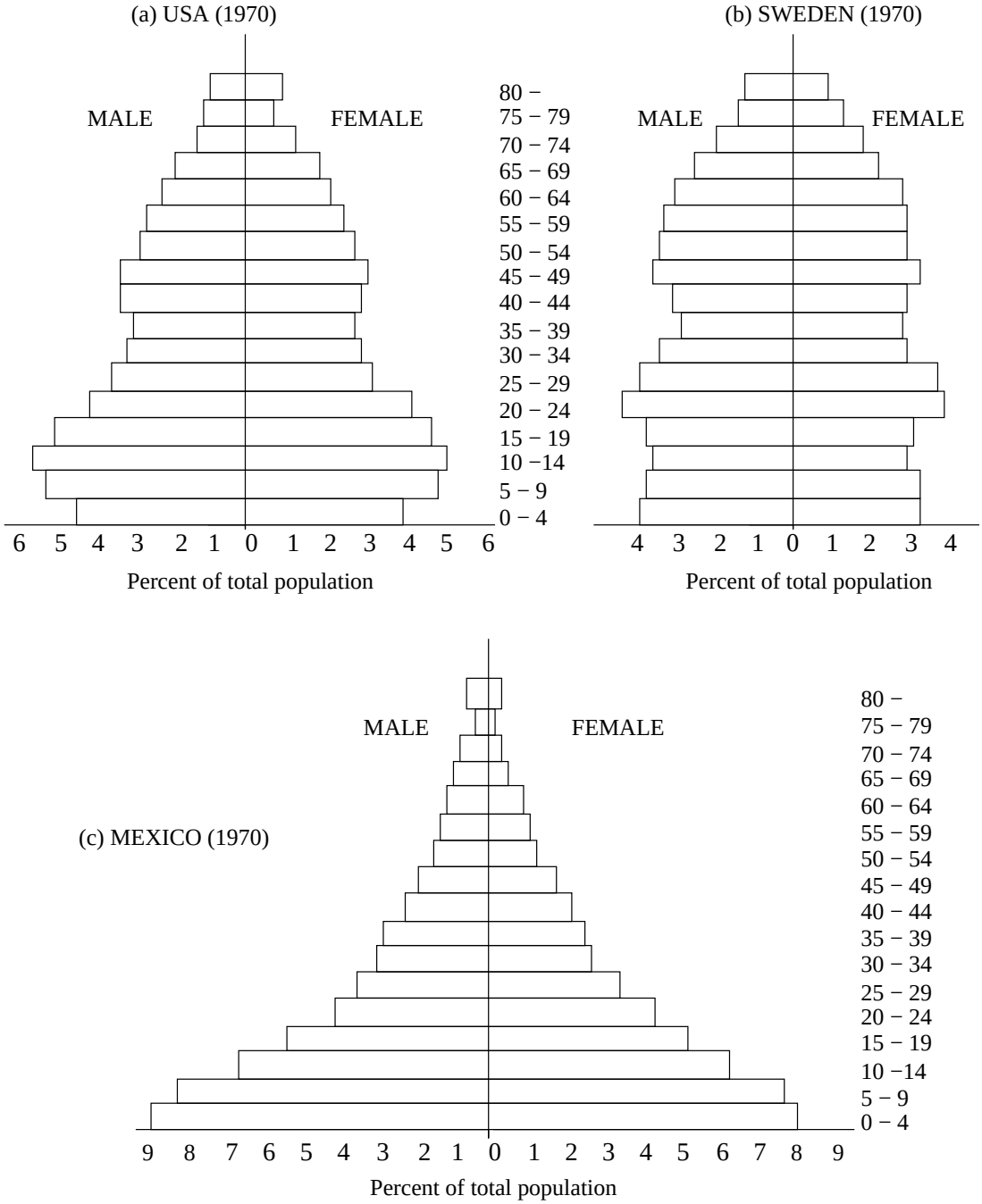
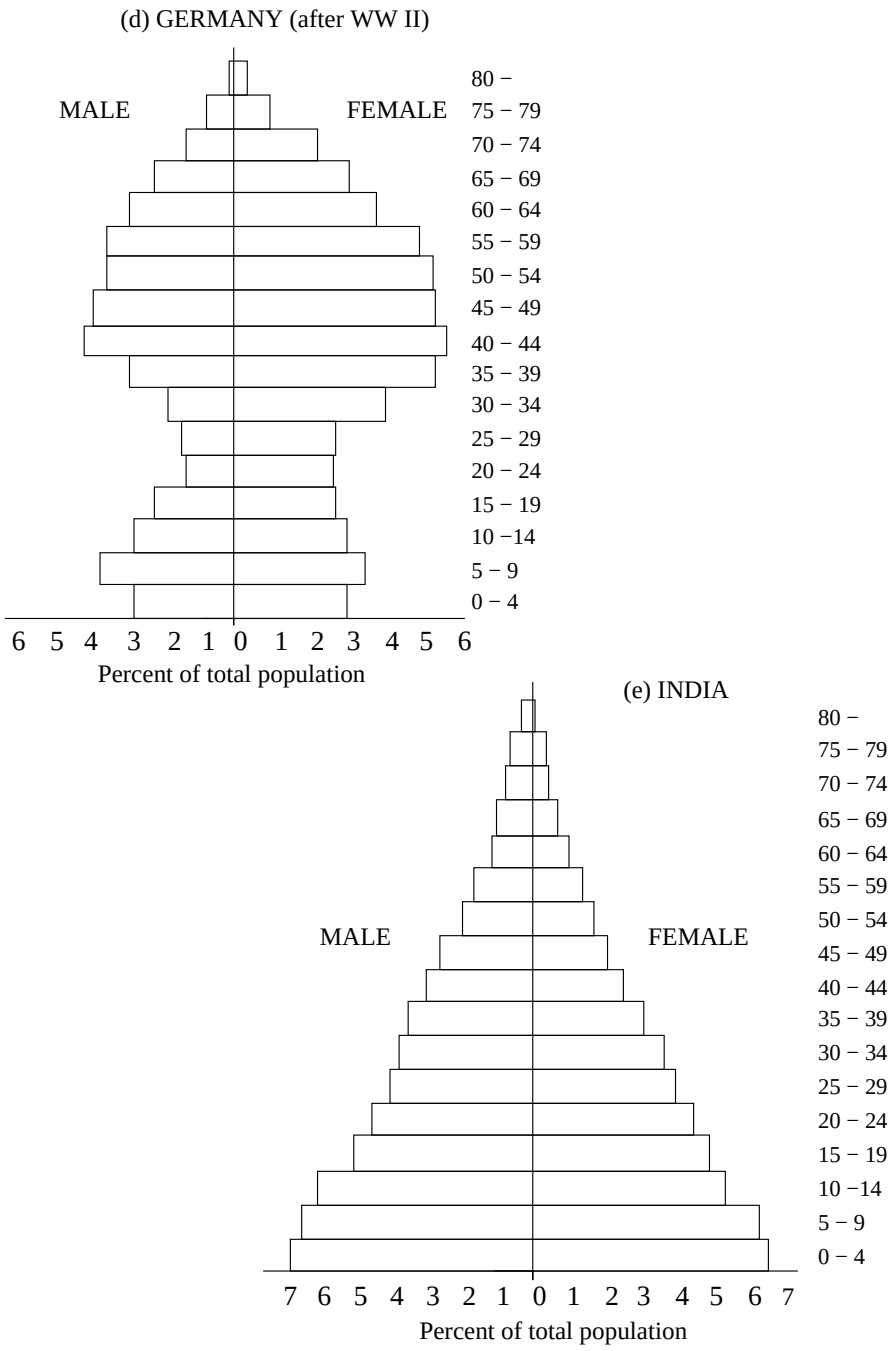


Figure 3.10: Age-sex pyramids (continued). (d) Germany after World War II, (e) India (1990)



3.12 Demographic transition

In a country called UTOPIA, in the Utopian year 2001, the CBR is 30 and CDR is 20. A large number of deaths in Utopia are due to a disease called **'computeritis'**. Thirty years later, an effective medicine for the disease is in the market. This reduces the CDR by 1 every subsequent year for the next ten years, after which time, CDR remains constant. However, CBR does not change throughout.

1. Plot the difference, $CBR - CDR$ as a function of years starting from 2001, till year 2060. Call it Plot 1.

2. What can you say about the rate of natural increase (and growth rate) of population in Utopia over the 60 years — from year 2001 to 2060?

3. Explain the nature of the graph. Comment on the regions of the graph before and after 2030.

4. Speculate about the values of CBR and CDR in Utopia after 2060.

5. Suppose that by 2040, the people of Utopia 'feel' the 'pressure' of increasing population. All happy and *aware* families begin to reduce the birth rate in the family. Over the subsequent years after 2040, the CBR reduces by 1 every year for the next ten years and remains constant after that.

6. Make a new plot of the difference, $CBR - CDR$ as a function of years till 2060 to indicate the new situation.

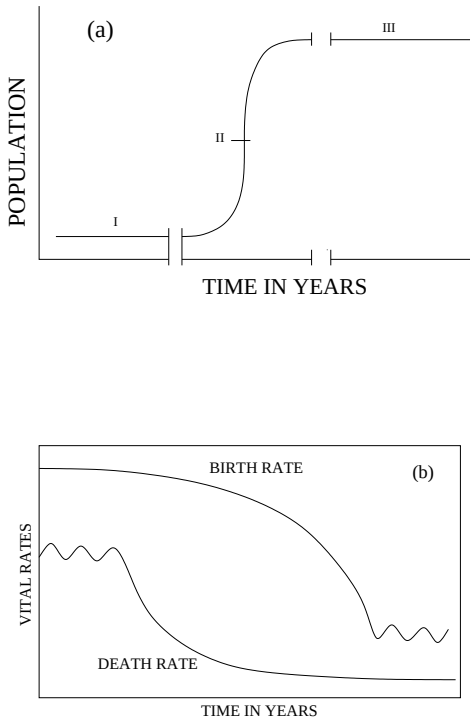
7. Comment on the growth rate of Utopia over the 60 years — from 2001 to 2060 in the new situation.

8. What changes can be observed in the graph? Comment on the different regions of the graph.

9. Once again speculate about the future values of CBR and CDR in Utopia. Are your new speculations different from your earlier ones?

Now, follow a discussion of the **Demographic Transition Model**, briefly outlined below.

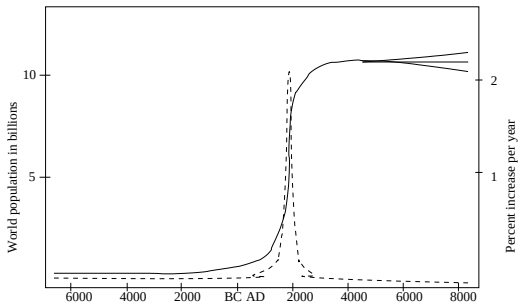
Figure 3.11: Schematic representation of demographic transition: (a) the three stage model, (b) details of the transition region.



Demographic Transition Model

In pre-modern societies, say a few hundred years ago, birth and death rates were high throughout the world. They were also in equilibrium — did not vary drastically with time. This caused a certain slow, steady rate of population increase. In industrialised societies today, there is a similar slow and steady increase in population. This time, however, it is a result of low birth and death rates. The changeover from the earlier equilibrium to the later one is termed the **demographic transition**, and theories describing the process of changeover are termed **demographic transition models**. Demographic transition is the central event in the recent history of human population.
Modern versions of the model distinguish 3 to 5 stages in the transition. The 3-stage model is shown schematically in Figure 3.11 (a) [16]. The transition begins with a decline in the death rate, usually precipitated by advances in

Figure 3.12: Demographic transition in historical perspective.



medicine, particularly, in public health, nutrition, or both. Some years later the birth rate also declines, primarily because of changes in the perceived value of having less children. In the period between the decrease in death rate and the decrease in birth rate population increases rapidly. Before the transition, birth rate is constant but the death rate fluctuates. After the transition death rate is constant and birth rate varies. This can be seen in the details shown in Figure 3.11 (b).
Now, attempt the following questions.

1. Revise the activity in Section 3.6. Comment on whether the population has a;ways been a problem, or it is a transitory one in terms of human history. Justify your answer.

2. If all the nations in the world achieved near-zero growth rates, can we say that the future population will be small? Justify your answer and describe some possible scenarios.

If you argued correctly, you would conclude that the 'exploding' population is a transitory stage in human history and will 'soon' (in historical time scales, how many centuries?) be over. This can also be inferred from Figure 3.12, which shows world population (solid line) as well as annual growth rate (dashed line) as a function of time from the past. The values of population and growth rates have also been extrapolated well into the future. What is uncertain, however, is how large the future population will be and what combination of birth and death rates will sustain it.

3.13 Urban populations

The first three activities concern the cities and towns of our country:

- estimates of their populations and growth,
- finding out the population of often visited places — cities, towns and districts,
- quantifying their change over time,
- listing the causes of these changes, and
- implications of these changes for our lives.

The last activity in this section deals with megalopolises (large cities) of the world.

3.13.1 Populations of known Indian cities and towns

This activity will familiarise you with calculating the deviation of estimated values from actual values.

1. In Table 3.8, write down your rough guess for the population of the given cities of India, for the census years 1971, 1981 and 1991. (You will find some of these values in this book. However, make an estimate without looking for it.)
2. Guess the population of the city, town or village you live in, and your 'home' town. Add them in the last rows if these are not included among the cities listed above.
3. Look up the actual population size of each city given above from the census report of the respective years. You will find this information in the Manorama Year Book of the respective years, or a book on Census Report analysis [6]. You may ask the respective municipal or corporation officials. You may also find some information in Table 3.9. How close were your guesses to the actual values? Calculate the percentage deviation of your answers from actual values as follows,

$$Percentage\ deviation = \frac{100 \times (actual\ -\ your\ estimate)}{actual}$$

Table 3.8: Estimates of population of cities

City	In Year 1971	In Year 1981	In Year 1991
Delhi			
Mumbai			
Madras (Chennai)			
Calcutta			
Chandigarh			
Bhubaneshwar			
Bangalore			
Ahmedabad			
Hyderabad			
Patna			
Jaipur			
Thiruvananthapuram			
Visakhapatnam			

4. Which city has the fastest growing population in the present decade? Discuss the possible reasons for its growth.

3.13.2 Growth of Indian cities

Study Table 3.9 and discuss the patterns based on the questions raised below.

1. Fill the last column in Table 3.9. Find out the values.

2. Which is the city with the largest population?

3. Which is the fastest growing city or town?

4. Are the cities with the highest population also the fastest growing ones? What could be the possible reasons for the situation?

Table 3.9: Population of a few Indian cities in 1981 and 1991.

City	Population		% Growth Rate
	1981	1991	Decadal
Patna	3,019,201	3,623,225	
Ahmedabad	3,875,794	4,788,820	
Raipur	3,796,553	3,902,609	
Mumbai	8,243,405	9,908,547	
Thane	3,351,562	5,244,679	
Jaipur	3,436,172	4,719,257	
Madras	3,276,622	3,795,028	
Calcutta			
New Delhi			

3.13.3 Rural and urban populations

This activity involves comparison of rural and urban population, population density and growth patterns in some districts of Maharashtra.
Table 3.10 gives the district-wise population statistics of some selected districts of Maharashtra State according to 1981 Census [30]. The table also includes the corresponding values for the State and the country. Study the table and engage in the activities suggested below.

1. On a map of Maharashtra State, showing district boundaries (given in Appendix C), name the districts and mark the location of the district headquarters.

2. Rank the districts given in the table in descending order of total population. Which is the most populous district in the state? Which ranks second? What fraction of the population of the state live in the district of rank 1?

3. Give reasons for the high populations of districts ranking 1 to 4.

4. Calculate the population density of the given districts. Rank the districts according to their population densities.

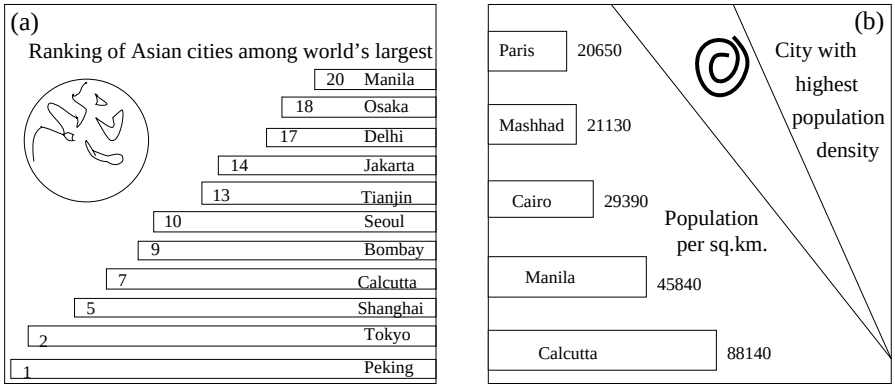
5. Do all the districts retain the same ranks as for the total population? Discuss possible reasons for the different ranks. Compare the history, geographical features, past and present agricultural and industrial roles.

Table 3.10: Population statistics of some districts in Maharashtra.

District	**Area sq.km.**	**Total popn.**	**Dec.gr.* rate %**	**Rur.pop.* in '000**	**Urb.pop.* in '000**
Gr.Bombay	603	8,243	38.38	0	8,243
Thane	9,558	3,352	47.28	1,865	1,486
Raigad	7,148	1,486	17.84	1,277	210
Ratnagiri	8,249	1,380	6.11	1,259	120
Nashik	15,530	2,992	26.49	2,064	928
Dhule	13,150	2,050	23.55	1,650	400
Jalgaon	11,765	2,618	23.52	1,960	658
Ahmadnagar	17,048	2,708	19.52	2,357	351
Pune	15,642	4,164	31.30	2,193	1,971
Satara	10,484	2,039	18.17	1,773	266
Sangli	8,572	1,831	19.08	1,437	394
Solapur	14,874	2,591	15.94	1,824	767
Kolhapur	7,633	2,465	22.57	1,194	622
Nagpur	9,931	2,589	33.54	1,120	1,469
Sub-Total					
Total (State)	307,690	62,784	24.75	40,791	21,993

Note:* Dec.gr. – decennial growth; Rur.pop. – rural population;
Urb.pop. – urban population.

Figure 3.13: Ranking and population density of a few megalopolises. From *Observer*, Bombay, (a) October 5, (b) September 17, 1994.



6. How do population densities of districts with ranks 1 to 4 compare with the population density of the state? Write a few lines on what information this comparison conveys to you.

7. Study the decennial growth rate (%) of the given districts. Compare the values for each of the given districts with the average decadal (or decennial) growth rate for the State.

8. If the growth remained the same over the next decade, what can you say about the population of these districts in 1991? What effect will this growth have on the population of the state as a whole?

9. How do the values of growth rates compare with that of India in the period 1971-1981 (see Section 3.6.3)?

10. Using the values given in the last two columns of the table, write an essay on the differences between rural and urban populations. Make guesses about the causes of such differences in absolute values and growth rates. You may also include anecdotes.

11. Write a play involving rural life in a district that you are familiar with, and the circumstances of the migration of its inhabitants members to the urban centres in the same or a different district. Your play must dramatically reflect reality.

3.13.4 World cities

This activity will familiarise you with the most populous cities of the world: their location and ranking. A discussion of population migration will be interesting. This should include causes of such migrations, such as, historical, geographical and economic factors.
Table 3.11 gives the population in millions in 1995 of the 20 most populated cities of the world [1]. Study the table and carry out the activities below.

1. Mark these cities on a world map provided in Appendix D.

2. Rank them in descending order of population (Complete column 4). How many of these cities have population greater than 10 million?

3. From a Gazetteer, [43] find the areas of these cities and calculate their population densities per square kilometre. Compare the values. Does the ranking of cities change in any way? Explain the differences.

4. How many of the 20 most populous cities are in the developed countries?

5. Urban population increase is related to many factors. You have already discussed them in previous activities. List some of the factors that you think must have contributed to the growth of the cities in the table. Find the important characteristics of each of these cities — their geographical location, trade strengths, cultural factors, etc.

3.14 Which countries affect world population?

This activity will show that small percentage changes in large populations will reflect as large changes in the world population numbers. This can be contrasted with the same percentage change in smaller populations. Hence, population dynamics of nations with larger populations is more likely to determine the net population increase of the world. The difference between population and population density is also clarified through appropriate examples of different nation states.
Population numbers for the 9 most populous countries of the world in 1991, (taken from the World Development Report [21]), are given in Table 3.12. Study the table and answer the questions posed below.

Table 3.11: Population of the most populous cities in 1995 (in millions).

Sr.No.	**City**	**Population in millions**	**Ranking**
1.	Los Angeles	12.2	
2.	Mexico City	15.5	
3.	New York	16.3	
4.	Sao Paolo	16.1	
5.	Buenos Aires	10.9	
6.	Rio de Janeiro	9.8	
7.	Paris	9.4	
8.	Cairo	9.4	
9.	Karachi	9.5	
10.	Delhi	9.5	
11.	Mumbai	14.5	
12.	Calcutta	11.5	
13.	Beijing	12.0	
14.	Tianjin	10.4	
15.	Shanghai	14.7	
16.	Tokyo	26.5	
17.	Osaka	10.6	
18.	Jakarta	11.0	
19.	Seol	11.5	
20.	Manila	9.0	

1. Are the countries ordered in any way? Express in what way they are ordered. Which is the most populous country in the world?

2. Look at the Globe, or its projection in an atlas. Identify and locate all the countries given in Table 3.12. Note the position and extent of each country with regard to its longitudes and latitudes. Estimate their relative sizes (areas).

3. Find the area of each country from a Gazetteer [43] and fill the appropriate column in the table. Compare their sizes.

4. Fill the last column in the table with the population density of each country. Are there differences in the new ranking of the countries in

Table 3.12: Population of 9 most populous countries in 1991.

Country	**Population in millions**	**Area sq.kms.**	**Popn.Density per sq.km.**
1. China	1,150		
2. India	844		
3. USA	253		
4. Indonesia	181		
5. Brazil	151		
6. Russian Federation	149		
7. Japan	124		
8. Pakistan	116		
9. Bangladesh	111		
The World	5,350		

descending order of population density?

5. Find out the population densities of Hong Kong, Singapore, New Delhi, Goa, Calcutta and Mumbai. Compare these with the population densities of the countries tabulated by you.

6. What information do you need to know before you can make an estimate, or hazard a guess, about the population of the country one year later? Ten years later? Find that information, estimate these values, and tabulate them.

7. Calculate a 20% increase in the population of China and India over 10 years (a decade). Calculate the resulting percentage change in the world population.

8. By what percentage will the world population change if there were a 20% decadal change in the population of Bangladesh?

9. Write the population values of China, India, Pakistan and Bangladesh, in the Indian place value system of numbers.

Table 3.13: Population of China and the World (in millions).

Year	**1950**	**1960**	**1970**	**1974**	**1981**	**1991**
China	558	654	772	825		
World	2501	2986	3610	3980		
Ratio, W/C						

3.15 Ratios, proportions: world population

This activity highlights that the ratio of most populated regions to world population has not varied very much over a century or so. This fact can be used to predict populations for some of the more populated countries or regions dominated by them. You should, at the same time, be able to recognize that it is far from accurate to estimate future populations using known past ratios. This is especially problematic for estimating populations of less populous countries.

1. Tabulate the ratios of the population of the five most populous nations in 1991 to the population of the world in that year.

2. Use the populations in 1991 of different countries given in Table 3.12. Add to this list the next 10 most populous countries. Find the ratio of the total population of the countries you have just added to the population of the first nine countries. Is this large or small? If an alien were to randomly (that would be a difficult task!) pick 100 persons, how many would belong to the Chinese population? How many would belong to Indian and US populations?

3. Table 3.13 gives the population of China and the World for different years since 1950. Population values are in Millions. Study the table and answer the questions addressed below.

    a. Enter the ratios in the last row.

    b. Do the ratios show vast variations, or are they relatively constant? Explain why that is so.

    c. Do the values of the ratios in the last row suggest that future populations can be estimated? Estimate the values in the last two columns.

Table 3.14: Estimate of world population in millions, 'continent-wise'.

Year	**1750**	**1800**	**1850**	**1900**	**1950**	**1975**	**1980**	**1990**
Oceania	2	2	2	6	13	21	23	30
Africa	40	40	40	50	200	400	460	600
Asia	450	600	900	1000	1500	2400	2650	3200
America	12	24	60	150	300	550	620	750
Europe	150	200	270	400	500	600	620	650
World(W) *	700	900	1200	1600	2500	4000	4400	5200
Ratios W/Europe								
W/Asia								
More Dev.	—	—	—	—	—	1150	1200	1250
Less Dev.	—	—	—	—	—	2850	3200	3950
% More developed	—	—	—	—	—			
% Less developed	—	—	—	—	—			

Note: * All estimates are rounded off to the nearest 10, or 100. Hence the totals may not tally.

d. What is the ratio of the population of the world to that of India in 1991? What information will you use to tell if the ratio has been constant over centuries? Over decades?

3.16 World population distribution patterns

You have already seen that certain relative quantities like ratios of populations of certain regions are more or less constant over long periods of time. This activity will sensitize you to patterns in populations of various continents over time. The similarity in the pattern over the last couple of centuries is noteworthy.
Study the data given in Table 3.14 and engage in the activities given below.

1. Fill in the blank rows for W/Europe (ratio of World population to population of Europe), and W/Asia (ratio of World population to population of Asia).

2. List the salient features of Table 3.14.

3. Did your list say that there is a pattern in the table that seems to change very little with time? What is that pattern? Discuss this pattern.

4. Try to explain any discrepancies or numbers that you feel 'do not fit'.

5. Use the pattern to make a reasonable estimate of future populations. Add a column corresponding to 2000 AD.

6. One does not make a phenomenal gain in doubling time unless annual growth rate is less than unity. (See Sections 3.8 and 3.5.2 to revise your idea of doubling time.) Many developed countries have, in the past, aimed for "zero growth" states (e.g. UK, Germany, and Sweden). What would that mean in terms of population increase, fertility rates, CBR, CDR, IMR etc.?

7. Give as many reasons as you can think of to justify that "zero growth" may not be a good population policy to follow. Can anything go wrong?

3.17 Demographic characteristics of India

By now you know that India is the second most populous country in the world. The activities suggested here will help you understand the demographic characteristics of various states in India.
Selected data from Ashish Bose's 1991 Census Analysis Report [6] is given in Appendix E. The population, according to the 1991 census, change in population since the previous census (in 1981), average percentage decadal growth rate, population density, sex ratio, and male and female literacy rates are given for all the States and Union Territories. An outline map of India with the State boundaries marked is also provided in Appendix F.
You may form five teams, each team working on one of the five activities suggested below. Each team then reports its findings to the entire group. Hints are provided to help you focus on one possible way of proceeding. You may ignore the hints and use any of your own creative methods.

1. Use the data of **population** in different states. Indicate on the map the population distribution in the country. Discuss the significance of

Table 3.15: Classifying population according to literacy rates.

Category Name	**Literacy Rate %** among Males	among Females
A1	> 75	> 75
A2	> 75	50 - 75
A3	50 - 75	50 - 75
B1	50 - 75	25 - 50
B2	25 - 50	25 - 50
C1	> 50	< 25
C2	25 - 50	< 25
C3	< 25	< 25

the pattern obtained in your map. *Hint: Study the table carefully and note the maximum and minimum population. Select some ranges of population that you want to differentiate. For instance you can choose five ranges, equally spaced between the maximum and minimum — very highly populated, highly populated, moderately populated, less populated least populated. Another way to choose the range is to find the average population of a state of India and differentiate the population as being much above it, above the average, around the average, and so on. Choose different shades of colour pencils or crayons, or a different pattern (hash, dots, long or short dashes, etc.) to indicate the different population ranges.*

2. Indicate on the map of India the **population density** of various states. *Hint: Use a strategy similar to the one above.*

3. On a map of India, indicate the **sex ratios** in different states. *Hint: Divide the total range of values of sex ratios into several convenient slabs (smaller ranges). Indicate the lowest slab by the darkest colours and user progressively lighter shades of the same colour for slabs of higher values.*

4. Show the pattern of **literacy rates** in the country on the map of India. *Hint: You could use the classification system given in Table 3.15. As in the activity above, you may use shades of a colour to indicate decreasing literacy rates.*

5. Show the pattern of **population growth rate** across the different states of India. *Hint: Use the average growth rate of the country as a whole to suitably divide the range of growth rates into 5 or more slabs. Indicate the information using colours or hashes.*

6. This activity is to be attempted by all the teams. Find the values of the five demographic parameters given in the table for three regions of the world given below. How do the Indian states compare with these three regional averages? Discuss team-wise the comparison of each parameter. The regions to be compared are: the world, 5 least developed countries, and 5 most developed countries.

3.18 The population debate

The class discusses the following conferences on population held under the auspices of the United Nations.

- 1974 Bucharest Conference on Population,
- the 'World Population Plan of Action' (WPPA) that was drafted and the repercussions of that,
- the conference in 1984, and
- the conference in September 1994.

3.18.1 Preparing for the debate

It is understood that a debate will be conducted on the lines of the 'UN Conference on Population' to evolve a 'global population policy'. This is done in a session prior to the actual debate so as to give all participants time for adequate preparation for the roles they will play in the debate. To this end, students are also provided a list of participants to the debate (which need not include the whole class, the remaining being 'mute spectators'), and the **agenda** for the debate. List of participants are representatives of 'real-life' groups, some of which are listed below.

- Policy Shapers — International Organizations like U.N.Fund for Population Activities (UNFPA), U.N.General Assembly, World Bank

- Funding Countries — USA, Japan, Germany
- Pronatalists
- Antinatalists
- 'Developmentalists'
- National Organizations — U.S.Agency for International Development.
- Less Developed Nations

3.18.2 Agenda

1. **UN Representative** — Perception of the population problem. This includes an introduction to the United Nations and UNFPA, outlines history of global population growth and the role of United Nations in striving for a consensus and global action on this issue.

2. **Nations** — Representation by each participating nation giving its emphasis, priorities and present programmes related to the population issue. Brief outlines of their plans either as policy shapers or their expectations from different aid agencies are presented.

3. **Non-Government Organizations** — Present their stand on the population issue, description of their population–related activities, future plans, targets and outlay for action.

4. Population plans put to debate.

5. Summary of consensus arrived at.

6. Outline of the Global Population Policy Draft.

Bring out a Global Population Policy Draft, with signatures of all participants to the conference. Compare this with previous drafts. Note any differences and discuss in the class. Encourage differences.

3.19 The story of three farmers

This story uses some of the quantitative reasoning developed in the activities above. It is also a cue to revisit some of the issues involved in the survival of humankind. This story should be repeatedly discussed after other relevant activities have been attempted. It will be referred to under different topics. It is an indication of how interlinked are the issues at the interface of science, technology and society.
The story begins ....
Ahamed, Bali, and Carlos were three youngsters, who decided to become wheat cultivators after obtaining a degree in agriculture in the year 1990.
At the end of 1991, Bali and Carlos had managed to procure an acre of land. The local politician gifted Ahamed 3 acres of land in 1991.
In the first year, they were inexperienced. At the end of 1992, each found that he had reaped 10 Kg. of wheat per acre of land he owned.
In subsequent years, the three farmers adopted different techniques of agriculture. Ahamed's technique added 10 Kg of wheat per acre in each subsequent year.
Bali found a technique by which the yield per acre was equal to the square of the number of years he worked on it.
Carlos doubled his yield at the end of every year.
First, discuss the problem and its scope. Then, based on the story, answer the following:

1. In A.D. 2000, what will be the yield of Ahamed, Bali and Carlos?

2. Plot a graph showing the total yield of each farmer in the years 1992 through 2000 AD.

3. Based on your graph, write a few lines describing the nature of increase for each farmer in mathematical terms, e.g. is it linear, non-linear, or exponential? Justify your answer quantitatively.

4. Write a page on what you think of the above fictitious situation. Can the situation be realized? If it is not realizable, why not? List the limitations. If it can be realized, discuss the consequences of such differential increase of yields of the three farmers. Imagine that a third of the farmers in a country were like Ahamed, a third like Bali, and the rest like Carlos. What might be the social, economic, scientific, technological, cultural, and any other consequences?

5. There is a law that economists refer to as 'the law of diminishing returns'. Find out about this law from the library. Weave the consequences of this law and extend the story of three farmers in your own creative way.

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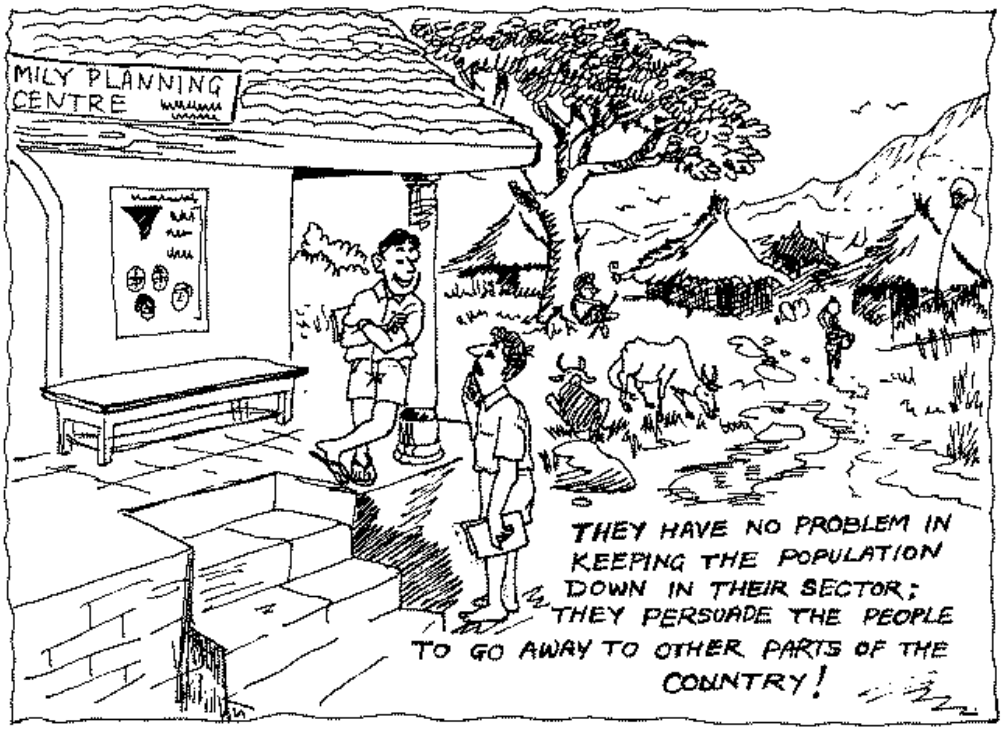
[59] U.N.D.P. *Human Development Report 1994*. Oxford University Press, Delhi, 1994.

[60] David Waddington. *Science for Understanding Tomorrow's World: Global Change*. International Counci of Scientific Unions and UNESCO, Paris, 1994.

[61] I. Waldron and R.E.Ricklefs. *Environment and Population: Problems and Solutions*. Holt, Reinehart and Winston, Inc., New York, 1973.

[62] Margaret Wolfson. *Changing Approaches to Population Problems*. Oxford and IBH Publishing Co., New Delhi, 1978.

Figure 3.14: **In lighter vein**



(Adapted from a cartoon by R.K.Laxman in *The Times of India*, July, 1975.)

Appendix A

Questionnaire on survival of humankind

1. Do you feel that the human species, as it is today, should survive? (CIRCLE YOUR CHOICE)

   (a) No, humankind should not survive.

   (b) Not sure if it should survive.

   (c) Yes, for 50 to 500 years.

   (d) Yes, forever.

   (e) Yes, but not sure how long.

2. If your answer above was (a), (b), or (c) list your reasons for feeling that human species should not survive, or should do so for a limited time. If you chose (d) or (e), pass on to the next question.

3. Do you feel that the human species, as it is today, will survive?

   (a) No, humankind will not survive.

   (b) Not sure if it will survive at all.

   (c) Yes, for 50 to 500 years.

(d) Yes, it will survive, but not sure how long.

(e) Yes, forever.

4. If your answer to the above question 3 was (e), list your reasons for feeling that the species survival assured. If you chose (a), (b), (c) or (d), pass on to the next question.

5. In this and the following five questions, tick the option that closely reflects how you feel about the statement made.

   Statement : Human species is facing problems.

   (a) Agree

   (b) Partly agree - Partly disagree

   (c) Disagree

   (d) Unsure

6. Statement : Survival of humankind is threatened by the present problems.

   (a) Agree

   (b) Partly agree - Partly disagree

   (c) Disagree

   (d) Unsure

7. Statement : Humans can overcome the present problems.

   (a) Agree

   (b) Partly agree - Partly disagree

   (c) Disagree

   (d) Unsure

8. Statement: Humans will face newer problems that threaten their survival in the future.

(a) Agree

(b) Partly agree - Partly disagree

(c) Disagree

(d) Unsure

9. Statement: Humans can overcome future threats to their survival.

   (a) Agree

   (b) Partly agree - Partly disagree

   (c) Disagree

   (d) Unsure

10. Statement: Human survival is a threat to the survival of other living beings.

    (a) Agree

    (b) Partly agree - Partly disagree

    (c) Disagree

    (d) Unsure

11. What will be the time taken for humans to overcome the present threats?

    (a) Less than 50 years.

    (b) About 50 to 500 years.

    (c) Greater than 500 years.

    (d) Never.

12. If you did not choose (e) in Question 3 above, (that is if you are unsure of the survival of the human species), list the problems faced by humankind (list in any order). Indicate briefly against each item, the source of your information (newspapers, magazines, teachers, text-books, parents, friends, TV, radio, etc.). If you have chosen (e) in Question 3, pass on to Question 15.

13. Order the above list in descending order of threat (write the most threatening problem first, followed by the next and so on). Indicate against each item whether humans will overcome that problem by writing Y (yes), N (no) or US (unsure).

14. If you have answered Y (yes) to any of the items above, indicate briefly the possible ways to overcome the problem.

15. If the circumstances were such that either humans or the other living species could survive, what would you opt for?

    (a) Survival of human species.

    (b) Survival of species other than humans.

    (c) Hard to choose.

16. Do you need more information to get a clearer idea about the survival of human species?

    (a) Yes. In the following areas .....

    (b) No. The issues involved in the survival of human species is clear to me.

    (c) No. The issues involved in the survival of human species do not concern me at all.

Appendix B

Population quiz

Sample Quiz

1. Name the important factors that determine the change in population size of a nation.

2. What is the present population of the world? (Estimate knowing the figures for 1991, and the annual percentage growth rates.)

3. What was population of the world in 1971 and in 1901?

4. What is the estimated population of India at present? What was it in 1981? What was it in 1971?

5. What was population of India according to the 1991 census report?

6. What was the average % decadal (in ten years) population growth rate of the world during 1971-81? What is it for India?

7. Name the five most populous countries at present. Rank them in descending order of population.

8. Do the growth rates of the world in the present decade differ from those a century ago? How would you describe the present trends of change? Decreasing / Increasing / Constant?

9. Which is the most populous state in India? Give an estimate of its present population.

10. Which state of India is the most densely populated?

11. What is the average sex ratio for India, that is, how may females would you find on the average for every 1000 males?

Appendix C

Map of Maharashtra

You may make as many copies as you need for the activity in Section 3.13.3. Since the names of the districts are not given, you need to find and mark that information before you begin the task. Given below (Fig C.1) are the age-sex pyramids of Greater Bombay and Maharashtra in 1971. Write a paragraph on the nature of these pyramids in 2000 AD.

Figure C.1: Based upon Survey of India map [30]

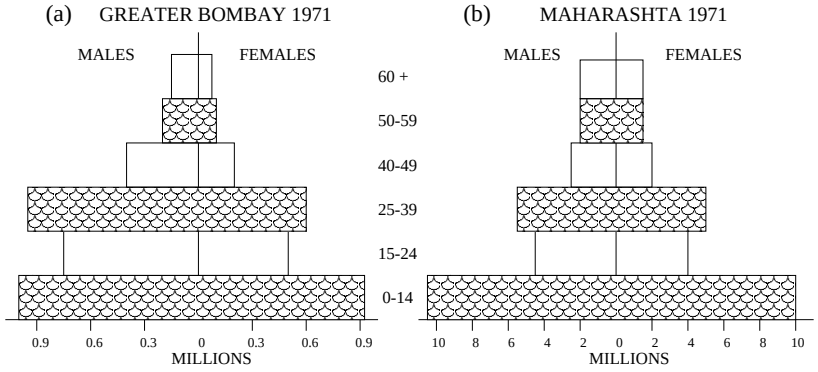
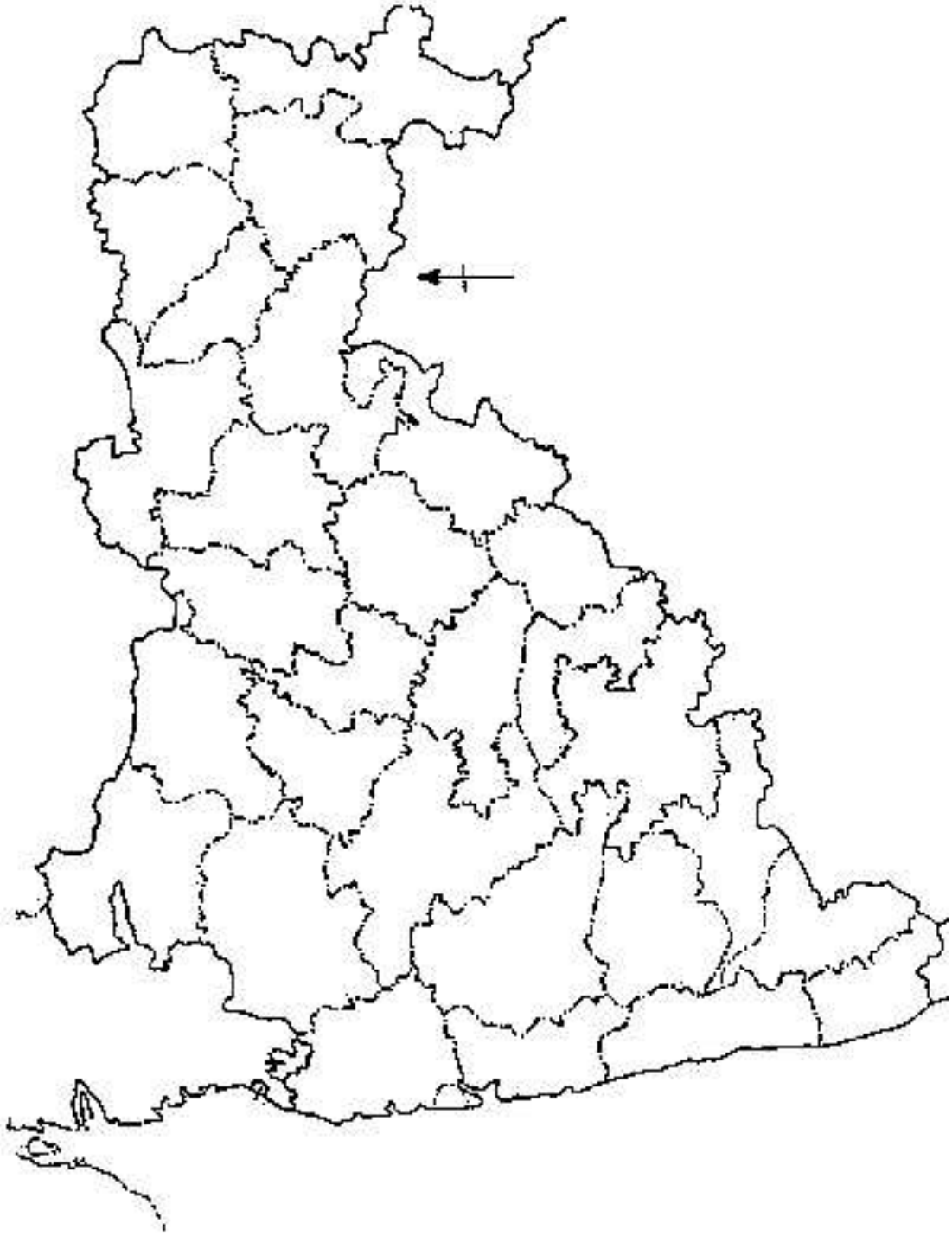


Figure C.2: **Political map of Maharashtra, 1991**



Appendix D

Political Map of the World

You may make as many copies of the map given overleaf as you need for the activity in Section 3.13.4.
Figure D.1 gives (a) the population density of a few countries, and (b) population of a few cities. Write a paragraph each on (i) how india compares with other countries in terms of population density, and the important differences, and (ii) populous cities of the world.

Figure D.1: Adapted from *Observer* (a) June 27, '94 and (b) Jan.3,'95.

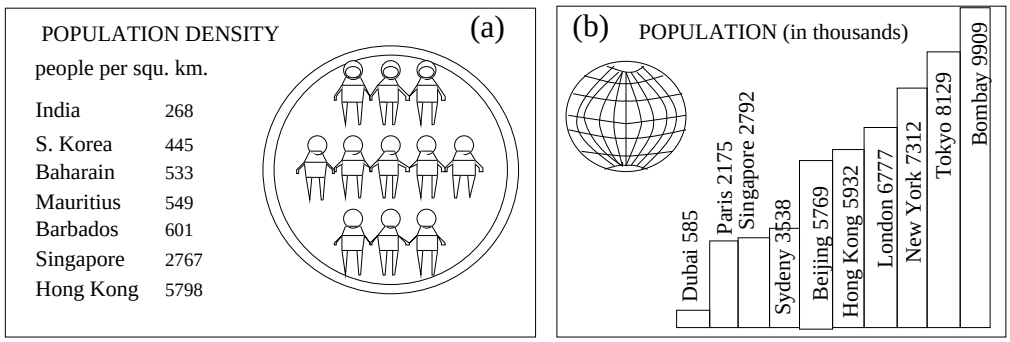
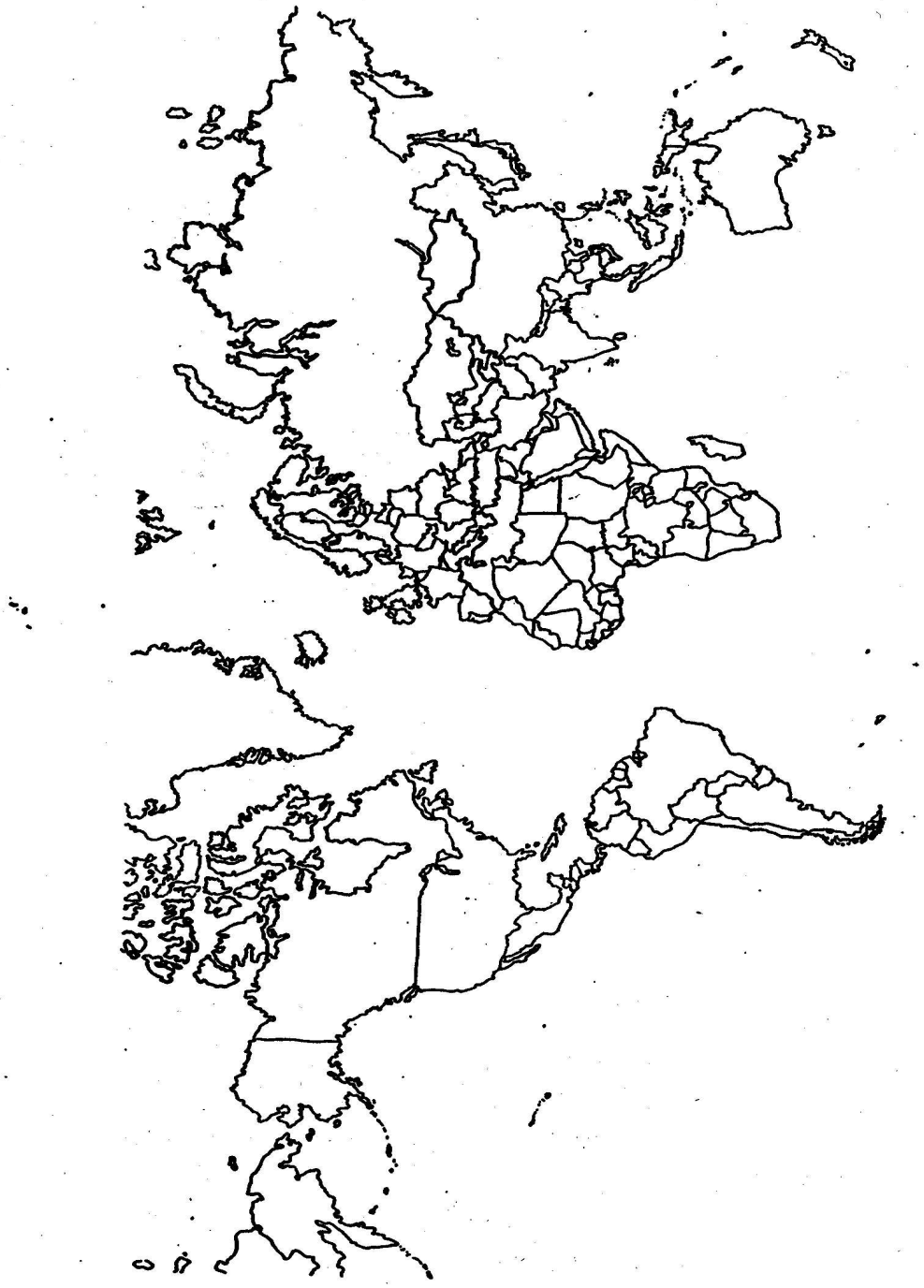


Figure D.2: **Political map of the World**



Appendix E

Indian census data, 1991

Data related to the States and Union Territories of India is given in Table E.1 and E.2 (taken from discussion of 1991 census report by Ashish Bose [6]).

Table E.1 Population, and Male, Female and Total literacy rates

Table E.2 Population density, Decadal growth rate in % and Sex ratio

Table E.1: Total population and literacy rates in States and Union Territories.

State	**Popn.**	**Tot. Lit.** Rate (%)	**Male Lit.** Rate (%)	**Fem. Lit.** Rate (%)
Andhra Pradesh	66304854	45.11	56.24	33.71
Arunachal Pradesh	858392	41.22	51.10	29.37
Assam	22294562	53.42	62.34	43.7
Bihar	86338853	38.54	52.63	23.1
Goa	1168622	76.96	85.48	68.20
Gujarat	41174060	60.91	72.54	48.50
Haryana	16317715	55.33	67.85	40.94
Himachal Pradesh	5111079	63.54	74.57	52.46
Jammu & Kashmir	7718700	—	—	—
Karnataka	44817398	55.98	67.25	44.34
Kerala	29011237	90.59	94.45	86.93
Madhya Pradesh	66135862	43.45	57.43	23.39
Maharashtra	78706719	63.10	74.80	50.50
Manipur	1826714	60.96	72.98	48.64
Maghalaya	1760626	48.26	51.57	44.78
Mizoram	686217	81.23	84.06	78.09
Nagaland	1215573	61.30	66.09	55.72
Orissa	31512070	48.55	62.37	34.40
Punjab	20190795	57.14	63.68	49.72
Rajasthan	43880640	38.81	55.07	20.84
Sikkim	403612	56.53	64.34	47.23
Tamil Nadu	55638318	63.72	74.88	52.29
Tripura	2744827	60.39	70.08	50.01
Uttar Pradesh	138760417	41.71	55.35	26.02
West Bengal	67982732	57.72	67.24	47.15
Union Territories				
Andaman, Nicobar	277989	73.74	79.68	66.22
Chandigarh	640725	78.73	82.67	73.61
D & N Haveli	138542	39.46	52.07	26.1
Daman & Diu	101439	73.58	85.67	61.38
Delhi	6370475	76.09	82.63	68.01
Lakshadvip	51681	79.23	87.06	70.88
Pondichery	789416	74.91	83.91	65.79
India	**843930861**	**52.11**	**63.86**	**39.42**

Table E.2: Population density, decadal % growth rate and sex ratio (females per 1000 males) for States and Union Territories (*)

State	**Popn.Density /sq.km**	**Decadal growth %**	**Sex ratio**
Andhra Pradesh	241	23.82	972
Arunachal Pradesh	10	35.86	861
Assam	284	52.44	925
Bihar	497	23.49	912
Goa	316	15.96	969
Gujart	210	20.80	936
Haryana	369	26.28	874
Himachal Pradesh	92	19.93	996
Jammu & Kashmir	—	—	—
Karnataka	234	20.69	960
Kerala	747	13.98	1040
Madhya Pradesh	149	26.75	932
Maharashtra	256	25.36	936
Manipur	82	28.56	961
Meghalaya	78	31.80	947
Mizoram	33	38.98	924
Nagaland	73	56.86	890
Orissa	202	19.50	972
Punjab	401	20.26	888
Rajasthan	128	28.08	913
Sikkim	57	27.57	880
Tamilnadu	428	14.94	972
Tripura	262	33.69	946
Uttar Pradesh	471	25.16	882
West Bengal	766	24.55	917
Andaman & Nicobar *	34	47.29	820
Chandigad *	5620	41.88	793
D & N Haveli *	282	33.63	953
Daman & Diu *	906	28.43	972
Delhi *	6139	50.64	830
Lakshadvip *	1615	28.40	944
Pondichery *	1605	30.60	982
India	**267**	**23.50**	**929**

Figure E.1: **In lighter vein**

(Adapted from a cartoon by R.K.Laxman in *The Times of India*, 1970.)

Appendix F

Map of India

You may make as many copies of the map given overleaf as you need for the activity in Section 3.17. Since the names of the States and Union Territories are not given, you need to mark that information before you begin the task. Study Figure F.1 showing (a) Average annual growth rate (%) of urban population, and (b) number of illiterate females above 15 years of age, in some countries. Write a paragraph describing the situation.

Figure F.1: Adapted from *Observer* (a) October 14, (b) July 19, 1994.

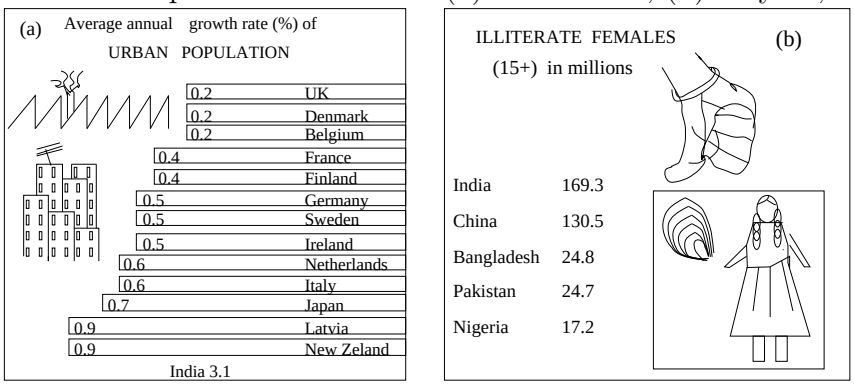
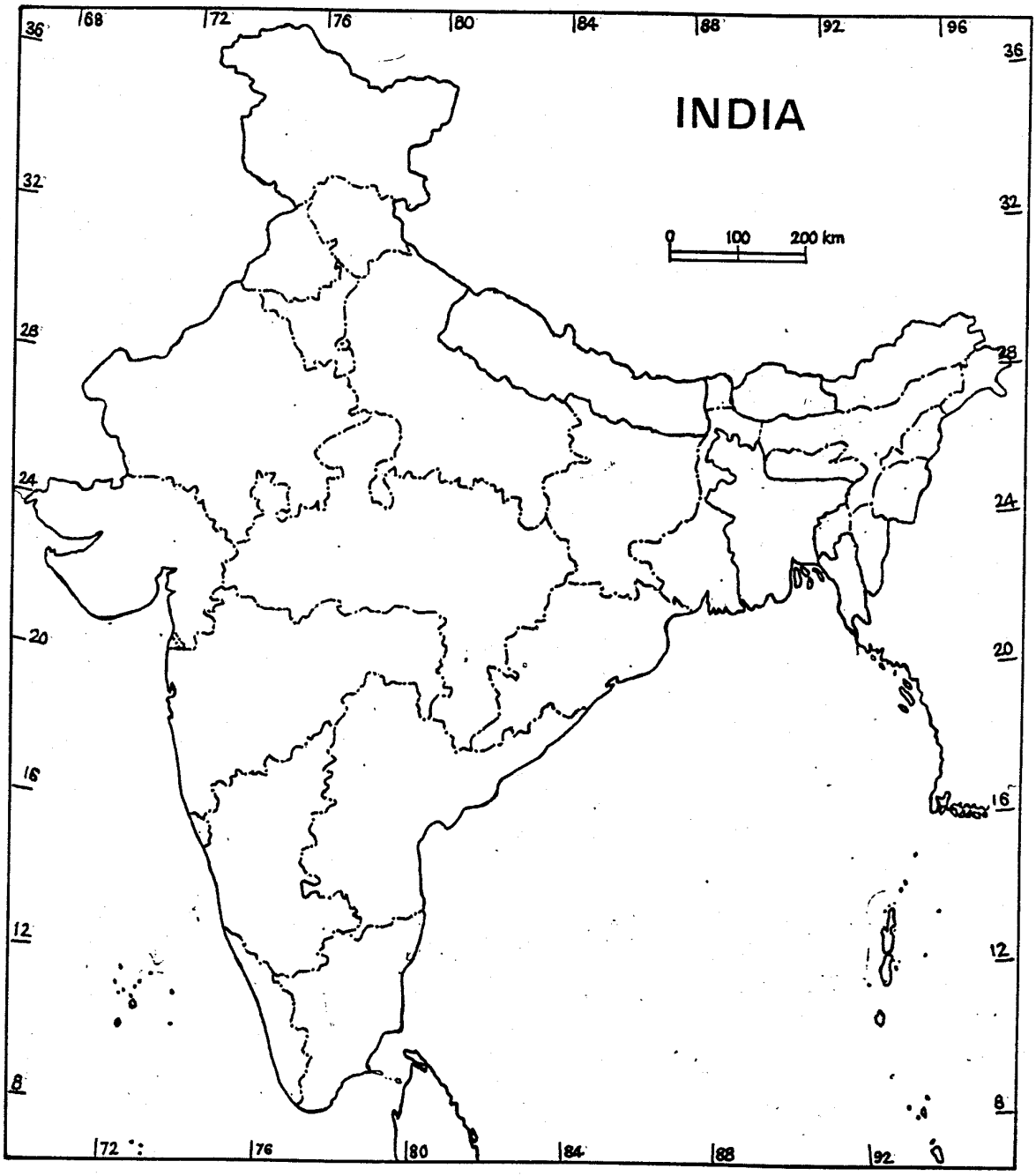


Figure F.2: **Political map of India**



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